VISUAL COMMUNICATION FOR BEHAVIOR CHANGE:
CHANGING USERS' BEHAVIORS REGARDING AIR QUALITY

Master of Arts Thesis
Jaeyong Lee
2016

VISUAL COMMU
FOR
BEHA
CHANGE

TITLE: VISUAL COMMUNICATION FOR BEHAVIOR CHANGE: CHANGING USERS' BEHAVIORS REGARDING AIR QUALITY

AUTHOR: JAEYONG LEE

SUPERVISOR: VIRPI ROTO

ADVISOR: VIRPI ROTO

PARTNER OF THE STUDY: PHILIPS

COMPANY SUPERVISOR: EDWARD TONINO

COMPANY ADVISOR: ESCANO SERRANO, CARMEN

—

Master of Arts Thesis
Collaborative and Industrial Design
Aalto University
Department of Design
School of Arts, Design and Architecture
Master's Programme in Collaborative and Industrial Design

Figure 1: <Smart Air Detector and Philips Smart Air (App)>

ABSTRACT

During the recent years, an increasing attention has been directed towards changing user behaviors and bringing long-term customer engagement through utilizing data from individual users. Due to this reason, numerous studies in the fields of psychology and sociology about the fundamentals of human behavior have been investigated to effectively nudge user behaviors through diverse Internet-connected devices: mobiles, tablet PCs and wearable devices. These Internet-connected devices try to intervene with the individuals' behaviors through visual elements on their screens. In other words, visual languages are used as a main medium in the digital products to communicate with users. For this reason, creating persuasive visual communication designs is becoming more important and deeper studies in the interconnection of visual communication design and behavior change has become necessary.

This Master of Arts thesis aims to find interconnections between visual communication design and behavior change, specifically focusing on people's diverse motivations in the context of air quality. To accomplish this goal, the study focuses on a particular research question; 'how would visual communication influence the behaviors of users who are differently motivated to improve air quality'. Based on related researches, the study also built a hypothesis; 'depending on the users' motivation levels in the context of air quality, the roles of visual communication for behavior change would be different'.

In the desk research, the study mainly investigated theoretical frameworks in the fields of human behavior and visual communication design. The acquired knowledge from the desk research was applied to the user research: an online survey, user interviews and Co-Design workshops. The findings and insights from these researches were used in an iterative product design project: Philips Smart Air Purifier. The final design outcomes consisted of Smart Air Detector, a data measuring device for real-time air quality, and Philips Smart Air, a mobile application connected to Smart Air Detector and Philips Smart Air Purifier. As the design goal of the project was challenging the selected target behaviors of target users, the outcomes were assessed through a 2nd user evaluation to figure out whether the created visual communication designs sufficiently influence users' behaviors or not.

Finally, the research question was answered. By designing visual languages that can increase the users' awareness and motivation in the context of air quality, interventions could effectively influence behaviors of users who are differently motivated. Since the study identified that being aware of a subject is the first step of change, increasing the users' awareness through visual communication is essential to develop their motivational levels, which ultimately influence the behavior change.

KEYWORDS

Behavior change, motivation, awareness, visual communication, visual perception, air quality

ACKNOWLEDGMENT

First and foremost, I would like to thank God. During 9 months, you have given me the ability to believe in my passion and pursue my dreams. I could never have done this without the faith I have in you.

I would like to thank all of all Philips people who participated from the beginning to the end of the study: Low Cheaw Hwei, Tonino Edward, Carmen Escaño Serrano, La Rovere Massimiliano, Wit Marloes de, Wijbrand Stet, David Oldenburger, Remco Timmer, Omna Toshniwal, Katja Leuschner, Jeanne de Bont, Jurrien Gosselink, Mark Graus, Guo Ning Hu and Hwang Kim.

Edward and Chewa Hwei, thank you very much giving me a chance working with Philips for this thesis. Especially Edward, as a company supervisor, you have shown great supports, I still remember that we have discussed this topic in the Singapore office, you tried to open more possibilities regarding this subject, and it has helped me very much.

Carmen, I cannot thank you enough for helping me, developing ideas together from the beginning, reflecting design processes, organizing all meetings with Philips people in Netherland and always being there to help me. This thesis would not have been possible without your help.

Virpi, thank you so much for being my supervisor and advisor. More than 10 times of meetings with you and all comments gave me a great motivation to well finalize this study.

I would like to thank all participants of the user researches: 104 participants from other countries, Alf Bae, Yu Chao Chien, Jinyun Kim, Hwang Kim, Rackho Choi, Wonsuk Jung, Goeun Park, Jungae Seo, Thomas Wahl, Amar Nath Shaw, Anton Annala, Sarasati Kushandani, Jeramy Antoinnete Tinaza, Seungho Lee, Sangwon Jung and Da-Woon Chung. Your participations and help gave me incredible insights during this study.

Appreciate again to Da-Woon Chung, you have help me not only for this study, but also for a place to work, a lot of free coffees and meals. Without your help, I would not finish this thesis in time.

Thanks to all people in National Institute for International Education (NIIED) who allowed me to get the scholarship during 2 years of study in Finland.

And, last but not least, thank you, father, mother, my brother, sister-in-law, my nephew, and all my friends for always supporting me from far east side of the continent. I truly love you all.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF APPENDICES

1. INTRODUCTION

During recent years, increasing attention has been directed towards changing users' behaviors and bringing long-term customer engagement through utilizing data from individual users. Due to this reason, numerous studies in the fields of psychology and sociology about the fundamentals of human behavior have been investigated to effectively nudge users' behaviors through diverse internet-connected devices: mobiles, tablet PCs and wearable devices.

The data people can access through these devices are also rapidly growing. People who lived in the 15th century experienced less data in their entire lifetime than people do in a single day in 2013 (Vince, 2013) and the amount of data in 2020, highly likely expands 50 times more than it did in 2011 (Mearian, 2011). Now people can use personal devices to manage their personal health data, e.g., calorie, running distance, the changes of weight on a daily basis and so on.

Regardless of these phenomenon, critical questions still remain. Does people really change their behaviors by seeing and understanding visualized data? How products influence the behaviors of people who are differently motivated? What kinds of psychological elements design should consider to influence individuals' behaviors? Amongst these questions, most important questions would be; how does visual communication through digital products ultimately change users' behaviors by supporting their optimal decision-making process (Ware, 2004).

Interventions trying to change users' behaviors through Internet-connected devices use visual languages as the main medium to communicate with users. Hence, interventions should consider the ways of creating persuasive visual communication, which ultimately interacts with the people and induces their behavior changes. For this reason, deeper studies in the intersections of visual communication design and behavior change are necessary.

This Master of Arts thesis aims to find interconnections between visual communication design and behavior change, specifically focusing on people's diverse motivations in the context of air quality. The findings from researches will be applied to a product: Philips Smart Air Purifier, to transform the knowledge to practical examples and to assess whether design outcomes successfully influence people's behaviors or not.

Researches related to data science: statistics, machine learning, data mining, data analysis and so on, will not be addressed in this thesis.

1.1 OBJECTIVES AND MAIN RESEARCH QUESTION

This master's thesis ultimately aims at achieving a holistic interpretation in the correlation between behavioral change and visual communication design for people who are differently motivated in the context of air quality. More specifically, the study focuses on the cognitive and psychological commonalities between the theories of behavioral change and visual communication design. Then, it investigates differently motivated people regarding air quality by proving a research hypothesis. After that it proposes practical design outcomes examining the target behaviors of a target user group – User Group 2, for the Philips Smart Air Purifier.

The main research question is:

How visual communication would influence the behaviors of users who are differently motivated to improve air quality?

1.2 METHODS AND IMPLEMENTATION

The objectives have been achieved through diverse researches: desk research, user research and a case study concerning user evaluation (See Figure 2).

Desk research is mainly conducted through literature reviews in the field of behavioral change and visual communication design. Literature reviews on behavior change aims to get a holistic interpretation of human behavior, i.e., how a behavior happens, what makes habitual behavior and more. Literature reviews on visual communication design includes the understanding of visual perception and practical techniques for data visualization.

In order to understand the different motivational levels of people in

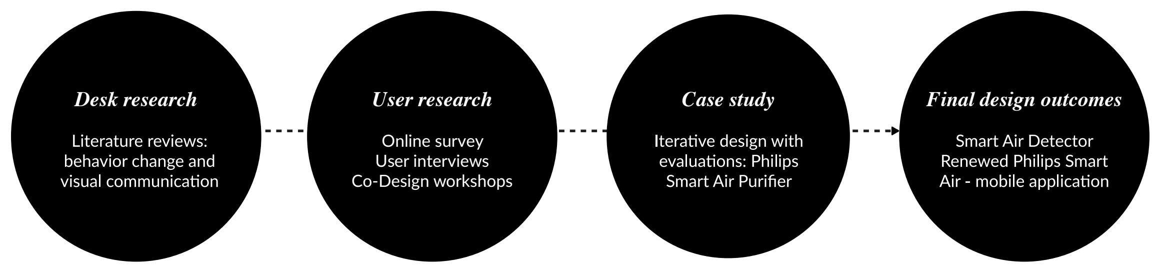


Figure 2: <Overview of process>

the context of air quality and preference, user research: online surveys, user interviews, and Co-Design workshops, have been conducted with a hypothesis. An online survey targeting for all user groups was implemented through 104 respondents who had diverse nationalities and experiences. User interviews, focused on User Group 2 and 3, had qualitative approaches to investigate users' motivation levels and contextual differences. Co-Design workshops invited people from User Group 2 in a design process, specifically focusing on their needs.

Through the desk and user research, the study goes further with an empirical case study – Philips Smart Air Purifier, through iterative design process with user evaluations. Iterative design process has been conducted three times in total including two times of evaluations. For the evaluations, Philips employees and users (User group 2) evaluated the initial design outcomes for each iterative process, and gave constructive feedbacks and critics.

As a final consequence, the study proposed two final design outcomes: 'Smart Air Detector' and the new 'Philips Smart Air Purifier mobile application'.

1.3 PARTNER OF THE STUDY

Philips is a multinational electronics company that aims to improve people's lives through meaningful innovations in the business of electronics, lighting and healthcare. During the study, Philips has been a partner not only sponsoring an air purifier, but also shaping the thesis topic together, reflecting the results of the study from the beginning to the end.

“ The critical question is how best to transform the data into something that people can understand for optimal decision making.”

- Ware, 2004

2. DESK RESEARCH

2.1 BEHAVIOR

Human behavior is complex. People choose different choices and behave differently based on uncountable diversities surrounding them. The early formal study of persuasion for behavioral change in social psychology began during the early 1900s, and social psychologists have established extensive researches to change people's attitudes and behaviors (Fogg, 2003, p.24). Regardless of this studies, there are still too many products or services failing to influence users' behaviors. Individuals often show unintended reactions or use products in different ways, which means that choice architects' (Thaler and Sunstein, 2009, p.14) interventions often fail to bring users' behavior changes. In order to minimize the failures and make successful persuasions for positive behavioral changes, a design should primarily understand how human behaviors work, why users fail to change their behaviors, and what methods could change their behaviors.

2.1.1 FACTORS AFFECTING ON BEHAVIORS

Behaviors mainly consist of 3 entities; human, information and context. These entities seamlessly interact with each other and ultimately influence behaviors (See Figure 3).

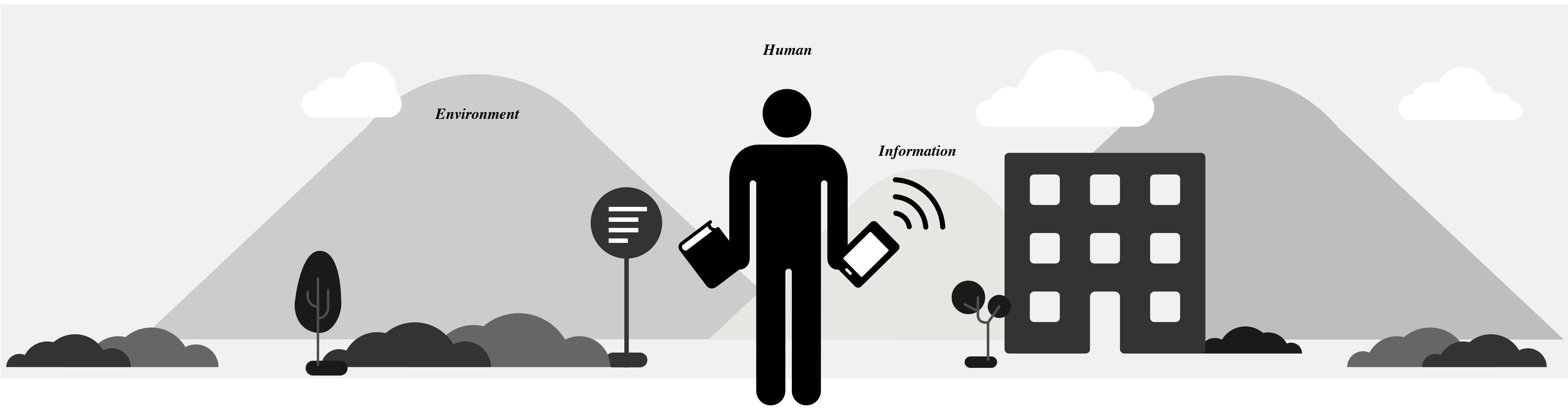
Human is an entity that accepts information, reflects context and finally behave an action. It has several variables: personality, preference, way of accepting information, knowledge and more. Among these unpredictable diversities, however, there is a trait that most people commonly share: the reflective and automatic systems. Thaler and Sunstein (2009, pp. 19–22) claims that there are two psychological systems a human brain regards in how we think and accept a subject. It explains that people sometimes show creative and clever choices, while they often make senseless and poor decision makings.

Table 1 illustrates clear differences between two contradictory systems of Human. The automatic system that is compared with Homer Simpson is intuitive, automatic and fast. It naturally reacts with certain stimuli e.g., one's eagerness to eat food, when the person did not have dinner. On the other hand, the reflective system that is compared with Mr. Spock is more reflective, rational and slow. When one makes a plan and follows it to achieve an intended goal, the person uses the reflective system. (Thaler and Sunstein, 2009, p.20)

Most of people use these two systems simultaneously. When they work on a specific task, they might use the Reflective system; working hard while thinking what are the primary goals of the task and checking the amount of workload and the deadline. After the task, they use the automatic system; watching a football game with a beer after work and skipping working out. The use of both systems makes people concentrate on work, create outcomes, and take a rest to release stress from work.

HUMAN

Figure 3: <Factors affecting on behaviors>



Automatic system	*Reflective system*
• Uncontrolled • Effortless • Associative • Fast • Unconscious • Skilled	• Controlled • Effortful • Deductive • Slow • Self-aware • Rule-following

Table 1: <Automatic and reflective system (Thaler and Sunstein, 2009)>

INFORMATION

Information is an entity conveying data to human. It conveys data reflecting context, and gives concepts that people could accept and understand to make a decision.

Delivered information could help users understand a subject throughout diverse visual symbols: texts, numbers, pictures, icons, graphs, colors, sound and so on. These symbols are delivered to Human via various media: print, broadcast, verbal language, digital media and more.

Information could be categorized into two sections based on the perceptual processing power of brain: sensory symbols and arbitrary symbols. Sensory symbols are effective, fast and stable across individuals, cultures and time. It does not require learning to understand the information, and it is naturally accepted through the early stages of neural learning. For example, individuals can immediately understand the meaning of a dog's image (See the left side of Figure 4). On the contrary, the arbitrary symbols have conventional facets of visualizations deriving its power from how people are educated. It does not have a perceptual basis, but the influence of it could be more powerful rather than sensory symbols. For example, the written word "dog" could be only understood by individuals learned about the word's meaning (See the right side of Figure 4). It derives its power from culture, therefore it is strongly dependent on the particular cultural environments of individuals. (Ware, 2004, p. 10)

Considering that those symbols are categorized by the perceptual processing of the human brain, it might have relations with the two brain systems of Human (See Table 1). The automatic system is fast and unconscious when it accepts certain information, which means that it uses the very early stages of neural processing – sensory symbols. When it comes to the Reflective system which is slow, controlled and self-aware and does not depend on a perceptual basis for it uses the late stages of neural processing – arbitrary symbols. Based on the purpose of delivering information to Human, sensory or arbitrary symbols could be used for stimulating different parts of the human brain systems which could lead different effects and results

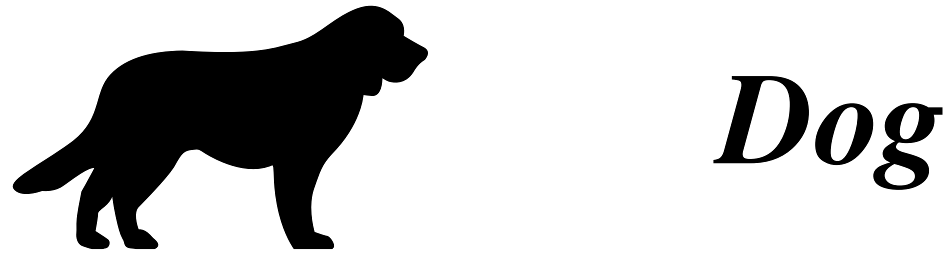


Figure 4: <Sensory and arbitrary symbol: dog and dog (adapted from Ware, 2004, p. 15)>

CONTEXT

Context is an entity that surrounds human and information; it refers to the entire situation, background or environment that is related to a particular subject or personality (Webster's new world dictionary. 3rd colleg, 1994) This affects behavior and attitude of people that are affected by a diversity of historical, situational and contextual factors (Dunn et al., 1994, p.595; Lucke, 2013, p.285).

The context consists of physical, personal, social and cultural context that tightly interwoven each other (See Table 2).

Physical context refers to the tangible and material objects or conditions that surround Human. It includes geography, environment, weather, climate and so on.

Secondly, personal context indicates one's personal variables derived from one's gender, age, values, belief, educational background, cultural background or state of mind.

Thirdly, social context reflects factors in the social structure and experience of individuals. It includes various social relationships of individuals with friends, family, communities and networks.

Lastly, cultural context refers to the influence of social norms, values, behaviors that expected to the individuals living in a particular country or community. (Radomski, 2008, p. 286)

As mentioned above (See 2.1.1 Human; Information), information could be categorized two symbols that are universally shared to all Humans (Ware, 2004, p. 12), like the psychological systems of human brain, at the least as a first approximation. However, accepting the information and transforming it to a behavior could be varied based on contexts of people (Raihani, 2013, p.1; Stokols, 1996, pp. 282-298). For example, a weather forecasting indicates that it would be rainy day in 60%. Depending on personal contexts of individuals, some people might consider bringing their umbrellas before leaving their home, but there would be also other people who believe the 40% of not rainy day or ignoring the information. The same information could be also differently interpreted based on the physical environment, e.g., some people who are staying in a country in which has strong acid rains might bring their umbrellas more than other people who are living in clean environments.

Physical context	*Personal context*	*Social context*	*Cultural context*
geography, environment, weather, climate	gender, age, values, belief, educational background, cultural background, state of mind	social relationships of individuals with friends, family, communities and networks.	social norms, values, behaviors that expected to the individuals living in a particular country or community.

Table 2: <Context: physical, personal, social and cultural (Radomski, 2008)>

In a nutshell, the shared visual systems and brain systems could make Human accept and experience information in similar ways, but it should be deliberated for contextual differences to bring a behavior change.

—

2.1.2 BUILDING A BEHAVIOR

Building a behavior consists of two parts: building an initial behavior change, and it turns to a habitual behavior. Inducing a behavior change is crucial, but sustaining the behavior as a habitual action is also important. This chapter will explain how a behavior can be formulated by Fogg (2009)'s behavior model, and how a habitual behavior can be made by Eyal (2014)'s Hooked cycle.

—

2.1.2.1 BEHAVIOR MODEL

Fogg (2009) presented a behavior model for persuasive design explaining the relationship between a behavior change and influential elements of it. Figure 5 illustrates a systematic principle of how a target behavior happens. Target behavior can be actualized through three main factors: Motivation, Ability (Simplicity), and Trigger. Motivation is the energy for action (Deci and Ryan, 2008, p. 182-185), Ability (Simplicity) refers one's capability to perform the target behavior or the level of simplicity of the behavior as itself (Fogg, 2009, p. 5), and Trigger is the spark plug causing to happen a behavior (Eyal, 2014, p. 7). When motivation and ability are sufficient enough with effective trigger, the likeliness to perform a target behavior will increase. All three factors must be happened in the same time, and absence of any factor makes the failure of achieving

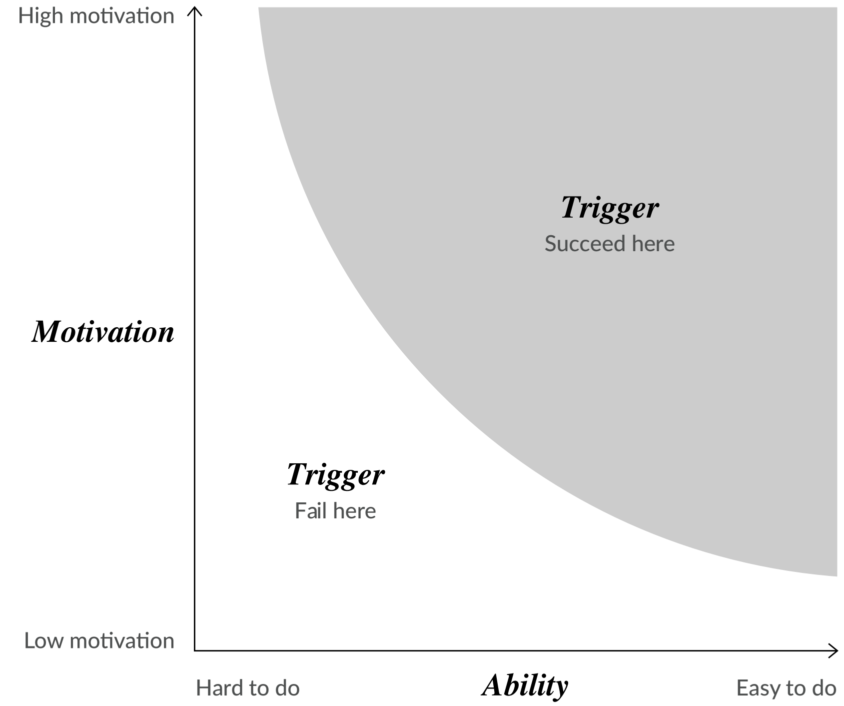


Figure 5: <Behavior model (Fogg, 2009)>

the target behavior. For example, even though one has a strong motivation and high ability, target behavior will not happen without a proper trigger. Motivation and ability can trade-off each other, but it is essential to have non-zero level of both motivation and ability to make a behavior.

MOTIVATION

As Figure 5 illustrates, Motivation in the behavior model is located in left side of the graph (Y-axis). Motivation literally means 'desire or willingness to do something.' The design for motivation purposes placing users in the upper side of graph to inspire for a targeted behavior. Choice architects could utilize motivation as a factor to persuade people behaving with certain actions or to dissuade otherwise, e.g., using images of the harmful effects of smoking on cigar packets. (Fogg, 2009)

In general, there are many studies on theory of motivation; from 1950 to 2008, the terminology 'motivation' had used in the titles or abstracts in over 65,000 psychological publications (Landy and Conte, 2007, p. 360). Among those studies, of course, numerous motivation models or frameworks have been investigated, but there is a widely known model for role of motivation in the perspective of increasing productivity of workers (Landy and Conte, 2007, p. 365).

$$\textit{Performance} = (\textit{Motivation} \times \textit{Ability}) - \textit{Situational Constraints}$$

In this model, it is important to understand that if motivation is almost at a zero level, only then can the high level of ability will not matter, for the product will be considered nil.

When it is compared to the behavior model (See Figure 5), the performance could be interpreted as the likeness of the performing target behavior. When a worker only increases the productivity of her/his working performance, it means that the interventions on changing a worker's behaviors are successful. Ability in this model is mainly used on describing one's capability and the situational constraints could be exchanged with contextual differences that environmental contexts have. This model can support a weak point within behavior model: none of the motivation, ability and trigger elements in the behavior model is considered contextual constraints as a critical element. Considering that context is an important factor in influencing a behavior (See 2.1.1 Context), taking both theories into account could offer a deeper understanding for changing one's behavior.

EXTRINSIC AND INTRINSIC MOTIVATION

Motivation varies not only in its levels, i.e., how much motivation is given, but in the orientation of motivation, i.e., what types of motivation. The motivation consists of mainly two segments: Intrinsic and Extrinsic motivation. Intrinsic motivation refers to doing something inherently and accordingly to its effects such as pleasure or joy. On the contrary, extrinsic motivation conveys some separable outcomes having an instrumental value. (Ryan and Deci, 2000)

AWARENESS

How is motivation created? When awareness is created by acknowledging a subject, motivation for a particular target behavior could be created. Prochaska et. al (2008) explained that the first start of change is initiated through having consciousness. In other words, the process of change starts with having awareness about a subject, and then people could have an initial motivation to behave in a certain way. For example, if one is unaware matters concerning air quality, the person would act according to a behavior that concerns improving air quality surrounding him. In the same sense, providing a detailed information regarding protective behavior would be also pointless in this situation (Brewer and Rimer, 2008).

ABILITY (SIMPLICITY)

Ability (Simplicity)is placed on the bottom line of the behavior model (X-axis). Increasing ability refers to making a behavior simpler than before or increasing one's capability to do the behavior. Increased Simplicity could be more likely achieved when the behavior is easily done with the support of interventions rather than increasing one's ability. Educating people to increase one's knowledge and expertise to make them do something is a difficult task because of human nature; people are fundamentally lazy. (Fogg, 2009)

Due to these reasons, increasing simplicity often refers to increasing the fundamental usability of a product or service in consumer

products. Well-designed products or services could minimize bottlenecks in usability issues; simplifying steps to a task, naturally guiding users to a target information, delivering relevant information and lessening mental efforts for doing something, and finally persuading users to change their behaviors.

TRIGGER

Trigger is the cue that makes people finally behave certain actions (Eyal, 2014, p. 7). It actualizes and transforms the motivation and ability to a tangible target behavior. Successful triggers have a few characteristics: First, one can recognizes it. Second, one can make an external or internal connection with the trigger to a target behavior. Third, the trigger happens when the behavior is possible to be performed. Among these conditions, the last option, 'Timing', is often missing or insufficient. As computer technology commonly takes the role of triggers in digital communication via SMS, Pop-Up Advertisement, E-mails and more, people often regard the triggers as distractions. The main reason why the triggers are regarded as interruptions is due to the timing of its delivery. To convert triggers to effective behavior change, choice architects should deliberate when it would be the opportune moments to deliver a certain trigger while considering what people truly want to have. (Fogg, 2003, p. 43)

EXTERNAL AND INTERNAL TRIGGER

Triggers takes the form of not only an obvious cue like a phone call, but also subconscious cues: external and internal trigger (Eyal, 2014, p. 41-51). External triggers are sensory stimuli that are embedded with information, which guides users to what to do next. For example, it could be a big button on a website or an image in a commercial alluring people to purchase a product. On the contrary, internal triggers are intangible. People cannot see, touch or hear. It manifests automatically in people's mind, when a product becomes connected with one's emotions these triggers. The emotions, specifically negative ones such as boredom, loneliness, frustration, confusion and more, are powerful triggers that influence users' behaviors. (Eyal, 2014, p. 48)

These internal triggers that stimulate an individual's negative emotions could be utilized for building effective interventions, but it should be well evaluated first before its delivery to users. Fogg (2003) claims that stimulating negative emotions via design would be questionable or even unethical (Fogg, 2003, pp. 222–223). However, it is also true that there are many successful internal triggers causing fear or anxiety to people regarding the public health, e.g., a nasty picture on a cigarette packet illustrating the anticipated results of smoking. It is a questionable issue but the essence of bringing negative emotions through internal triggers is that whether it is sufficiently deliberated for inducing positive results for individuals or not.

2.1.2.2 HABITUAL BEHAVIOR

Many people easily adapt to new technological products: measuring and analyzing one's own data but most of them fail to make the products essential for their lives or even use the products for a longer period of time. A research shows that one in ten people in the U.S. over the age of 18 owns an modern activity tracker but most products failed to drive a long-term engagement for majority of the users; a third of consumers who have owned an activity tracker stopped using the device within six months (Ledger and McCaffrey, 2014, pp. 2–4). Interventions should support not only on persuading the initial behavior change of users, e.g., encouraging people to start running, but also support helping people create habitual behavior, e.g., motivating users to run regularly for more than 3 months. In order to achieve the long-term engagement, putting users into a habitual cycle is essential.

TRIGGER, ACTION, REWARDS AND INVESTMENT

Eyal (2014) explains how products are habitually used in an everyday context. He claims that there are 4 steps: Trigger, Action, Rewards and Investment, to make a long-term user engagement.

Figure 6 illustrates the 'Hooked cycle'. When it is compared with the behavior model (See Figure 5), the trigger and action could be understood as the same elements that have been discussed above (See 2.1.1 Factors Affecting on Behaviors; 2.1.2.1 Behavior Model). The clear distinction between the two frameworks is that the 'Hooked cycle' deals with the aspect of after the behavior.

According to the Hooked cycle, the product or service should provide variable rewards to make a habitual behavior. Reward is a strong tool that creates constant user engagements; the level of the neurotransmitter dopamine dramatically increases when one expects a reward (Sapolsky, 2013). Unlike a plain feedback loop, the model emphasizes the variability of reward; predictable rewards do not create desire. It includes diverse types of rewards: social rewards by connectedness with other people, material resources, information, mastery, competence and completion.

Investment is the last step of the Hooked cycle. It occurs when users put their time, data, effort, social capital or money into the product or service. For example, after initiating using a web service, people would invite their friends, they would update own profiles, they would learn new features, and spend more time on it to improve their experience of using the product. By doing so, the investment brings more user engagements and forms a habitual behavior. It could be leveraged when a person's desire and a product is matched. To actualize it, the product should make more effective triggers, easier behaviors and intriguing rewards through the Hooked cycle.

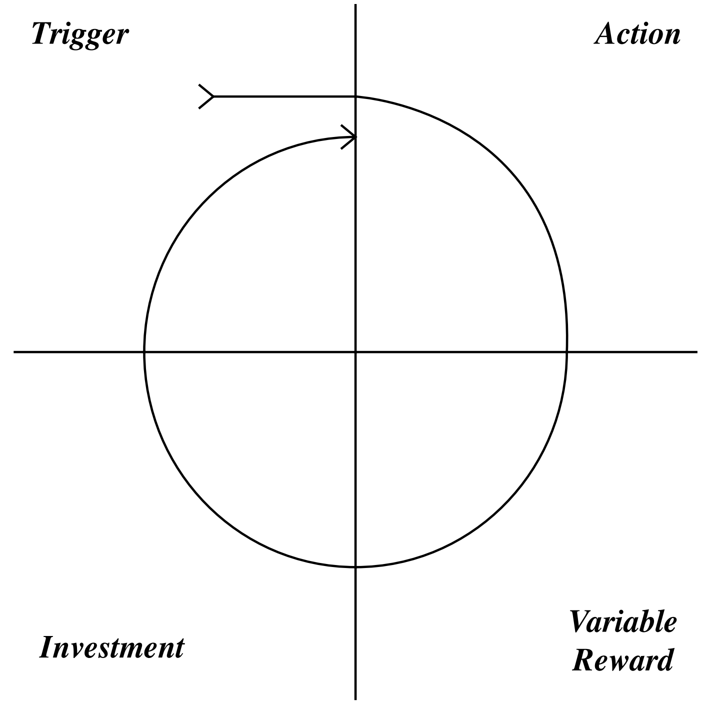


Figure 6: <Hooked Cycle (Eyal, 2014)>

2.1.3 CHANGING BEHAVIOR

The ultimate goal of behavioral studies is influencing people's behavior. Transforming one's behavior via interventions can be called different terms. Thaler and Sunstein (2009) named it "Nudge: altering people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives", Fogg (2003) referred to it as "Persuasion: changing people's attitudes and behaviors", Eyal (2014) labeled it "Habit-Forming: habitually altering people's everyday behaviors by products and services that designers intended", and Gibson(1977) claimed it to be called as "Affordance: perceived and actual properties of a thing determining how the thing could be possibly used".

The concept has been referred in different ways, but it shares one core idea: supporting individuals to make good or better choices. Helping people make good decisions and changing their behaviors have been actively examined for resolving social issues as well as improving customers' lifestyles, e.g., slowing down the speed of cars, decreasing smoking rates, reminders to take pills, enhancing children's eating habit and so on. Although at some instances, choice architects' interventions are unsuccessful, or people ignore it regardless of its intention. The worst scenario of a failed intervention is inducing bad decision making to people via unintended and unexpected results.

To prevent or minimize the failure, choice architects need to understand the fundamental reasons of unsuccessful interventions and consider the practical and effective ways of persuasion.

—

2.1.3.1 WHY DO WE FAIL?

According to a research, 81% of New Year's resolutions fail, and even 29% of the people fail within two weeks (Norcross et al.,2002, p.397-405). Why do they fail to change behaviors?

There are many theories on why people fail to change their behaviors, of course, but some studies claim that there are three main reasons why people often face distractions in making behavior change.

Firstly, those distractions happen when people are not aware of the need of change (Brewer and Rimer, 2008, p. 155). Since people do not know the anticipated effects of the behavior change, they cannot even think or try to make the change.

Secondly, people have two brain systems (Thaler and Sunstein, 2009, p. 20), and they are fundamentally lazy (Fogg, 2009, p. 5). People often make a new plan to achieve a certain goal in the beginning, but they easily lose their motivation when it comes to the implementation.

Thirdly, products or services that people adopt to change behavior are not enough to make the change (Norman, 2002, p. 1; Thaler and Sunstein, 2009, p.81-82). It is poorly designed by choice architects who insufficiently consider behavioral elements.

UNAWARENESS

Being aware about a subject is the first stage of change (Prochaska et al., 2008, p.101). If people are unaware regarding a subject, the necessity of change or the result of changed behavior, they are highly unlikely to change their actions (Brewer and Rimer, 2008, p. 155). Unawareness could disrupt increasing motivation for a target behavior, which consequently results to the failure of behavior change. It is caused by diverse reasons: user's low motivation about a subject, lack of information, low simplicity of accepting information so on and so forth. For example, if one does not have any interest regarding air quality, detailed data in the changes of outdoor air quality would not affect the person's behavior. If one has had no intriguing information or has had too detailed information regarding air quality, the lack of information or excessive information would also not be persuasive to change behavior. Therefore, the unawareness should be transformed to awareness by getting relevant and interesting information. Then, the awareness could increase motivation of a behavior, and it could make a basis for behavior change.

TWO DIFFERENT BRAIN SYSTEMS

People often fail to change their behavior because of their fundamental laziness (Fogg, 2009, p. 5). To understand this laziness, two different psychological systems: Automatic and Reflective system (See 2.1.1. Human), can give clues. This concept explains the reason why people sometimes show very creative and clever decisions, while oftentimes make senseless behaviors.

Thaler and Sunstein(2009) compare it with Homer Simpson and Mr. Spock, which represent an automatic system-oriented person and a reflective system-oriented person. Being Mr. Spock is ideal for every situation - making clever decisions and organized with complex problems, for sure, but there is always a Homer Simpson inside individuals determining unreliable behaviors, deciding choices that ultimately bring negative consequences.

On the surface level, it seems like Homer Simpson is wrong, and Mr. Spark is right. However, those two different systems have their own strengths to understand information. In detail, the automatic system (Homer Simpson) is fast and unconscious when it accepts certain information. The system is optimized to get a brief and simple information through sensory symbols (See 2.1.1 Information), which means that it would be effective when a product instantly nudges a user to induce quick responses. On the contrary, when the product intends to bring a deeper engagement for users, it could intentionally stimulate one's reflective system by providing arbitrary symbols.

POOR PRODUCTS

Well-designed products efficiently motivate users, and users can easily understand what is the next behavior they can do (Norman, 2002, p. 2). However, sometimes, creators assume or imitate techniques to make a product without proper understanding of human behaviors (Fogg, 2009, p. 1). Those designs are often poor, interventions are not persuasive, and it does not deliver any psychological cues to nudge people's behaviors. These poor products are still used in people's everyday lives and are inducing wrong consequences that are not intended. Choice architects who have the responsibility for building interventions that could bring change to an individual's behavior should deliberate the behavioral elements: awareness, motivation, ability(simplicity), trigger, context, information and experience of users, when they are supposed to influence people's lives in positive ways.

—

2.1.3.2 HOW DO WE CHANGE BEHAVIORS?

People have entered an era of technology where interactive computing systems are designed to change people's behaviors and attitudes. By following these changes, Fogg (2003) introduced the concept of "Captology: computer as persuasive technologies", and explained its three main roles: as tool, medium and social actor, to change people’s behaviors.

Computer technology as a tool increases capability. It makes activities easier or more efficient to do. It also leads people through a process and performs calculations or measurements that motivate individuals. Computer technology as a media provides vicarious experiences that motivate. Users can simulate the anticipated results of target behaviors by utilizing various media, e.g., text, sound, picture, video and more. Computer technology as a social actor creates relationships. It enables computers to trigger social responses with users such as rewarding people with positive feedbacks, modeling a target behavior or attitude and delivering social support. (Fogg, 2003, p. 24 -27)

Each role has very specific and diverse methods to practically actualize the persuasive interventions using computer technologies. The details of techniques that have been utilized in the following case study (See 4.4 Iterative design), and it will be described in the chapter 5. Final design outcomes.

2.2 VISUAL COMMUNICATION

The studies of behavior change have been conducted in various fields: psychology, sociology, Human-Computer Interaction(HCI) and so on. However, it does not have sufficient researches concerning design, even though most interventions aiming for alerting users’ behavior use visual factors as a main tool to communicate and interact with end-users.

Vice-versa, many designers also assume that accumulated data and visualization of designs could simply alter users’ behaviors (Fogg, 2009, p. 1). However, most of the data representation as itself, numbers, different types of diagrams, graphs do not have proper deliberations about human behavior. Sometimes even when information correctly indicates a result to users, they often do not recognize that they need to alter the concerned part of lives.

With these reasons, applying knowledge of visual communication design to the studies of behavior change and finding a correlation between the two areas could bring valuable inspirations to construct interventions that are more persuasive, understandable and clearer. If behavior change is a theory, the visual communication is a medium facilitating substantial changes in users’ contexts.

2.2.1 DATA, INFORMATION, KNOWLEDGE AND WISDOM

To clarify the types of contents that interventions convey to users, the study investigated the distinctions amongst data, information, knowledge and wisdom (Shedroff, 1994, p. 2-5) (See Figure 7).

DATA

The literal meaning of data is “facts and statistics collected together for reference or analysis” (OED Online, 2016). It is the product of discovery, research, gathering and creation. It is the basic material for creating communication, and is used as a source to build meaning. However, it is fairly worthless to most of people; it is not a proper product for communication: boring, meaningless, incomplete or inconsequential. At times, many designers suppose that their products deliver information to users, but the truth is that most of the time it is merely just data that is not transformed to information (Shedroff, 1994, p. 2).

Even though data has the characteristics of incompleteness and meaninglessness as a final outcome, it still has a correlation between each entity of data. The types of data are divided through its connection with other kinds of data: entities, relationships and

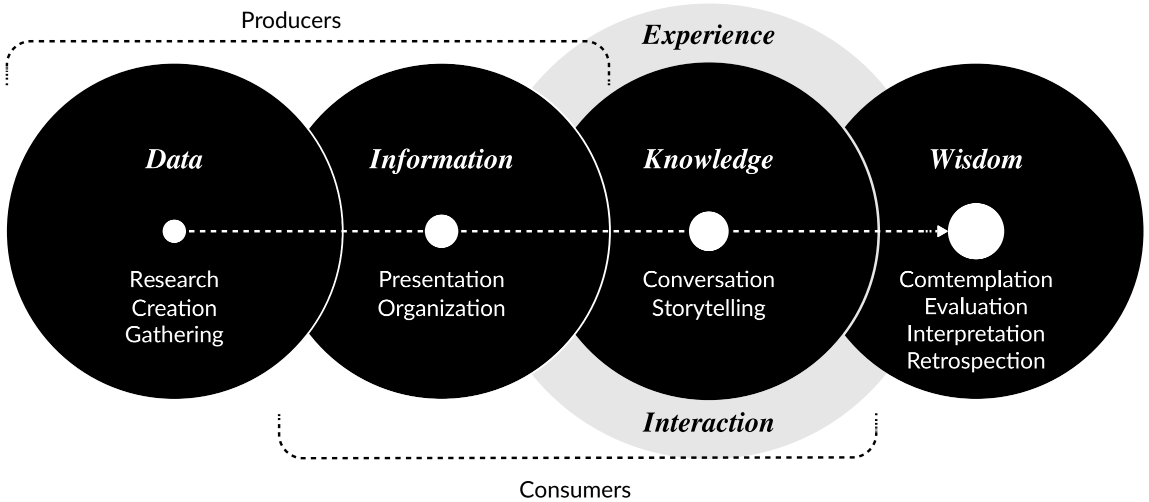


Figure 7: <Data to wisdom (Shedroff, 1994)>

attributes. Entities refers to data values that have independency. People, animals, fish or even hurricanes can be entities. Relationships build the structures of entities, e.g., a wheel as a part of a car, an employee of a firm and customer in a store. Attributes refer to something that is a property of an entity and cannot be thought of independently. For example, sausage is an attribute of hotdog, or books are attributes of library. (Ware, 2004, p. 23-26).

INFORMATION

In order to transform data to information with a communicative value, the data should be organized and presented in a way that conveys meaning. Information requires building meaningful relationships and insightful patterns from disordered data and presents it in an appropriate way in order to communicate with contexts around it. For example, color coding is good for stock-market symbols but texture coding is good for geological maps (Ware, 2004, p. 23). The same data sets could be represented in various ways by its purposes, and it can deliver different meanings and insights to perceivers.

KNOWLEDGE

Just as data can be transformed into information, information can be also converted to knowledge. Knowledge can be generated through interaction and experience. In other words, delivering mere information is insufficient to build knowledge; it should be accompanied with compelling interactions bringing experiences to people. This is the last step wherein a product or service could directly affect its users. (Shedroff, 1994, p. 4).

WISDOM

Wisdom is an abstract and philosophical concept compared to other levels. This “meta-knowledge” could be gained through experiences,

contemplations, evaluations, retrospections and interpretations, which are particular personal processes of thinking. It cannot be shared with others like other levels can do, while external supports can only offer opportunities. (Shedroff, 1994, p. 5).

—

2.2.2 VISUAL PERCEPTION

Our visual system is extremely sophisticated and well-engineered for perceiving visual stimulus (Van Essen et al., 1992, p. 419). When people are faced with a stimuli, it is delivered to our sense organs, e.g., eyes, ears and nose, and our sensory system transmits the information to the brain. For example, when people drive a car, they analyze an immensely rich source of information: reading traffic signs, checking destination, localizing and tracking vehicles and so on, and are control the car by understanding the information.

Accepting visual stimulus that convey data or information through perceptual experience is imperative to understand the role of visual communication; how human perception works and what types of stimulus role in certain ways. This section will investigate those diverse aspects of sensory stimulus in the field of psychology and semiotics.

—

2.2.2.1 BOTTOM UP VERSUS TOP DOWN PROCESSING THEORY

The ongoing theoretical argument amongst psychologists regarding the process of perceptual experience is that whether perception is dependent on the information in the stimulus or the perceiver’s expectations and knowledge based on a previous experience. The controversy in the processing of perception is mainly divided Gibson (1966)’s ‘bottom-up’ theory and Gregory (1970)’s ‘top-down theory’. (McLeod, 2007)

BOTTOM UP PROCESSING THEORY

Gibson (2002) claims that the human perception starts from information to the stimulus itself. He argues that perception requires innate mechanisms wherein no learning is needed for perceiving a subject, and there is enough information in our environment to make sense of the world in a direct and immediate way. The process starts from accepting raw sensory data to an increasing complexity of analysis through the visual system of human. In detail, one initiates an analysis of sensory stimulus such as light patterns, and this data is delivered to the retina where the process of transduction into electrical impulses begins. The impulses are passed into the brain where they trigger further responses along the visual pathways until they arrive at the visual cortex for final processing.

The Bottom up theory is also connected with the affordance theory (Gibson, 1977), which explains the reason why people perceive the surface of a subject, i.e., surfaces for walking, handles for pulling, space for navigating and more. The affordance of a subject ties to the theory of direct perception and explains the correlation between perception and human behavior (Ware, 2004, p. 18).

Since it explains the perception solely in terms of environment, it has critical evaluations wherein other elements could influence the perception, e.g., memories and previous experiences. (McLeod, 2007)

TOP DOWN PROCESSING THEORY

Gregory (1970) insists that perception is a constructive process. Since there is too many ambiguous information within our environment, people use higher cognitive information that stored in their brains, e.g., either past memories or experiences, to build an inference about what is out there. During this process, people are actively constructing their perceptions based on their surroundings and stored information. Tufte (2001) also supported this idea; perceptions change with experience, and it is context-dependent.

Just like the Bottom up theory, the top down theory also has had critical evaluations from psychologists, such as perceptual development; how can the neonate ever perceive, and underestimation to the richness of sensory evidences that is emphasized in the Bottom up theory. (McLeod, 2007)

Neither the Bottom up nor the Top down theory can explain all cases of visual perception. However, to interpret the holistic view of visual perception, it would be better seeing those theories as interacting each other to produce the optimal understanding of visual stimulus.

—

2.2.2.2 SENSORY VERSUS ARBITRARY SYMBOLS

As the previous research mentioned, there are two types of semiotic symbols – the study of signs and symbols and of their meaning and use (OED, 2016b), conveying information and stimulating different paths of perceptual experiences of Human: sensory and arbitrary symbols (See 2.1.1 Information). The sensory symbols refer to understandable visualizations without learning, arbitrary symbols are representations that must be learned (Ware, 2004, p. 10). It seems easy to classify in those ways, but there are ongoing arguments regarding the clear division.

Technically, there are very few sensory symbols in real life. Most icons, images and colors that are simply regarded as sensory symbols have conventional traits of being arbitrary symbols: individuals are already educated to understand the meaning of these in a cultural background. For example, people must learn to understand the dog icon (See Figure 4), i.e., if one has not seen a dog in her/his entire life, he would not understand the meaning of it. Ware (2004, p. 10) claimed that there are only few graphical languages consisting of entirely arbitrary conventions, and maybe there is entirely no sensory symbols.

However, distinction between sensory and arbitrary representations is imperative. Even if with a clear example of sensory symbols that can be clearly distinguished from arbitrary symbols, sensory symbols are still effective in delivering certain types of information by matching it to the early stages of neural processing.

According to the theory of sensory languages, the human visual system has evolved to a tool to perceive the environment, and people all fundamentally develop the same visual systems regardless of cultural differences (Ware, 2004, p. 12). It means that sensory symbols are relatively stable across individuals, cultures, regions and time. When it compares with the information perception theory, sensory symbols have some of the commonalities with Gibson (2002)'s Bottom up theory; human perception starts from informing the stimulus itself and no learning is required to perceive a subject. His affordance theory (See 2.2.2.1 Bottom Up Processing Theory) could be also examined through well designed sensory symbols that stimulate the visual sensory system; visual affordance for nudging one's behavior.

On the contrary, arbitrary conventional representation relying on culture; how much the person learned, can be comparable with Gregory (1970)'s Top down processing theory (See 2.2.2.1 Top down processing theory). In the theory of Top down processing, visual perception is based on one's stored information and experience, which has a similarity with arbitrary convention – knowledge in a culture. Since arbitrary symbols are based on one's knowledge, it is hard to convey complex meanings to a person who has not experienced or learned the meanings regarding the conveyed information. For example, the statement of "air quality PM 2.5 level is 340" would not deliver any meaning to a person who does not know anything about the air quality. Alternatively, in this case, the complexity of information requiring a perceiver's knowledge could be altered through sensory symbols to convey the meaning. For example, the PM 2.5 level could be visualized through the visible dust in the air that could help people recognize the level of air pollution. However, it would have constraints as well; the alternatively transformed sensory stimuli would not deliver the correct meaning of "PM 2.5 340", the perceiver can only assume the correct information.

Throughout the interpretation of diverse aspects of semiotic symbols, it seems possible to answer an intriguing question from Norman (2015); "does culture matter for product design?" Some information should be properly developed to focus on arbitrary conventions reflecting its context, but there will be a certain part of design that can be universally applied for almost everyone with various cultures.

In conclusion, the best way seems to be effectively combining sensory and arbitrary symbols to deliver information. Based on the context of conveying information and the purpose of interventions, choice architects could focus on either sensory symbols, arbitrary symbols, or both. The effective visual affordance could be achieved throughout the deliberation of harmonizing both semiotic symbols.

2.2.2.3 EMOTION FROM PERCEPTION

The recent studies of cognitive neuroscience have highlighted that human cognition accompanies not only information processing, but also an interaction with emotion. Investigations on neural systems demonstrate that the human mechanisms of cognition and emotion are tightly intertwined from a very early perception of reasoning for decision making (Phelps, 2006). Namely, especially visual stimulus, e.g., color, pictorial image, animation and more, could effectively bring emotional and experiential interactions from early recognition to decision making (Ackerman, 1990, p. 282).

Individuals could have emotional interaction by directly experiencing a subject, e.g., being afraid of bad air quality by having allergic symptoms due to an unhealthy air environment, but people can also alternatively learn to fear and avoid a subject by accepting visual stimulus, e.g., a realistic picture illustrating how the bad air quality actually affect one's health condition. This type of instructed learning will result in an emotional response when they encounter the learned situation, even though there was only an explicit, symbolic knowledge of the situation (Phelps, 2006).

There are also evidences that perceiving an emotional status from other stimulus could activate a mechanism that is responsible for creating one's emotion (Adolphs, 2003). For example, seeing a facial expression can trigger expressions on the viewer's own face in the absence of conscious recognition (Wallbott, 1991; Dimberg et al., 2000). The viewer perceives the facial expression, empathizes to the feeling, and alternatively simulates the emotional status. Especially, the investigation of Schultz et al. (2013) well demonstrates that visual stimulus – emoticons can significantly influence the decision making of people by stimulating emotional interactions – decreasing energy consumption of households consuming above the average.

Bringing emotional interaction to human perception is also often used in persuasive technology. Fogg (2003) explains that virtual simulation formed by sensory languages could bring alternative experiences of object and environment for persuasion. Namely, the emotional interaction conveying the experience of a subject through computer technology can be used for the purpose of changing people's behaviors.

2.2.3 VISUALIZATION

The conventional meaning of visualization refers to the construction of a visual image in the mind. However, as accessible quantitative data expands, the more likely we are able to access to graphical representations of data or concepts (Ware, 2004, p. 2). Specifically, data graphic or data visualization displays measured data by combination of points, a coordinate system, numbers, symbols, words, shading, and color (Tufte, 2001).

When visualizations are well and effectively designed, it could bring strong benefits to perceivers. In detail, effective visualization provides the ability to quickly comprehend large-scale or small-scale data, and help find the distinction of it (Ware, 2004, p. 3). It immediately reveals problems or critical points, so that perceivers can think about the substance rather than other unnecessary elements, e.g., methodology, technology or something else (Tufte, 2001, p. 13).

To make graphical excellence representing data in an effective way, the visualization should have clarity, precision and efficiency through diverse skills: visual, artistic, empirical, statistical and mathematical techniques. Tufte (2001) introduced various visual principles to generate graphical excellence with maximizing data-ink – none-erasable core of a graphic and the non-redundant ink arranged in response to variation in the numbers represented – and minimizing non-data-ink or redundant data-ink.

First, make the right choice of design through: sentences, text-tables, tables, semi-graphics, and graphics. Second, make the complexity of data accessible by combining words, numbers, and pictures; combining words and pictures is nearly always helpful. Third, make the proportion and scale balanced: line width, lettering and the shape of graphic.

He claims that most of "Chartjunk – a data graphic having non-data-ink or redundant data-ink, or that could even distract the viewers from understanding information", comes from the "interior decoration of graphics" that does not tell anything new for viewers. However, it does not mean that visual aesthetics is unnecessary for data graphics. Beauty is a great persuasive recommendation (Ackerman, 1990, p. 271), and the visual simplicity of design, which can be also regarded as 'the visual aesthetics', is one of the fundamental elements for building graphical elegance (Tufte, 2001, p. 177). The challenge for all designers who create data graphics is that how to build the excellence of data graphics with attractive displays telling only necessary information.

2.3 OPPORTUNITIES AND CHALLENGES

The results of the desk research demonstrate that there are feasible commonalities between the studies of behavior change and visual communication throughout diverse theories. By interpreting and combining those study areas, design interventions could have a more open possibility to examine the influence of visual communication to users' behavior change.

In detail, understanding the core elements affecting on human behaviors: human, information and context, gives us an idea of the traits of each entity and the relationship of it. Studies in building behavior including the behavior model: motivation, ability (simplicity) and trigger, and the hooked model for creating habitual behavior: trigger, action, rewards and investment, gives plentiful insights from shaping a behavior to constructing a sustainable behavior change. Interpretations for reasons why individuals fail to change and practical knowledges for changing behaviors through persuasive technologies highlight diverse opportunities to influencing people's behaviors by questioning 'why and how'. In addition, by comprehending various theories in visual communication: the classification of data, information, knowledge and wisdom, visual perception and visualization, the thesis study can have a much clearer interpretation of various angles in visual perception, emotional interaction from visual stimulus, and technical knowledge to create graphical elegance and efficiency.

Still, there are many challenges beyond the basic understanding human behavior and visual communication. As the main research question declared; how visual communication would influence the behaviors of users who are differently motivated to improve air quality, there should be empirical investigations researching on how people who have different motivation levels about air quality understand and accept information, and what would be able to make them keep motivated to change their behaviors.

“The number 52 doesn’t give me something. It may be the same as 15,000 for me.”

- A participant in a Co-Design workshop

3. USER RESEARCH

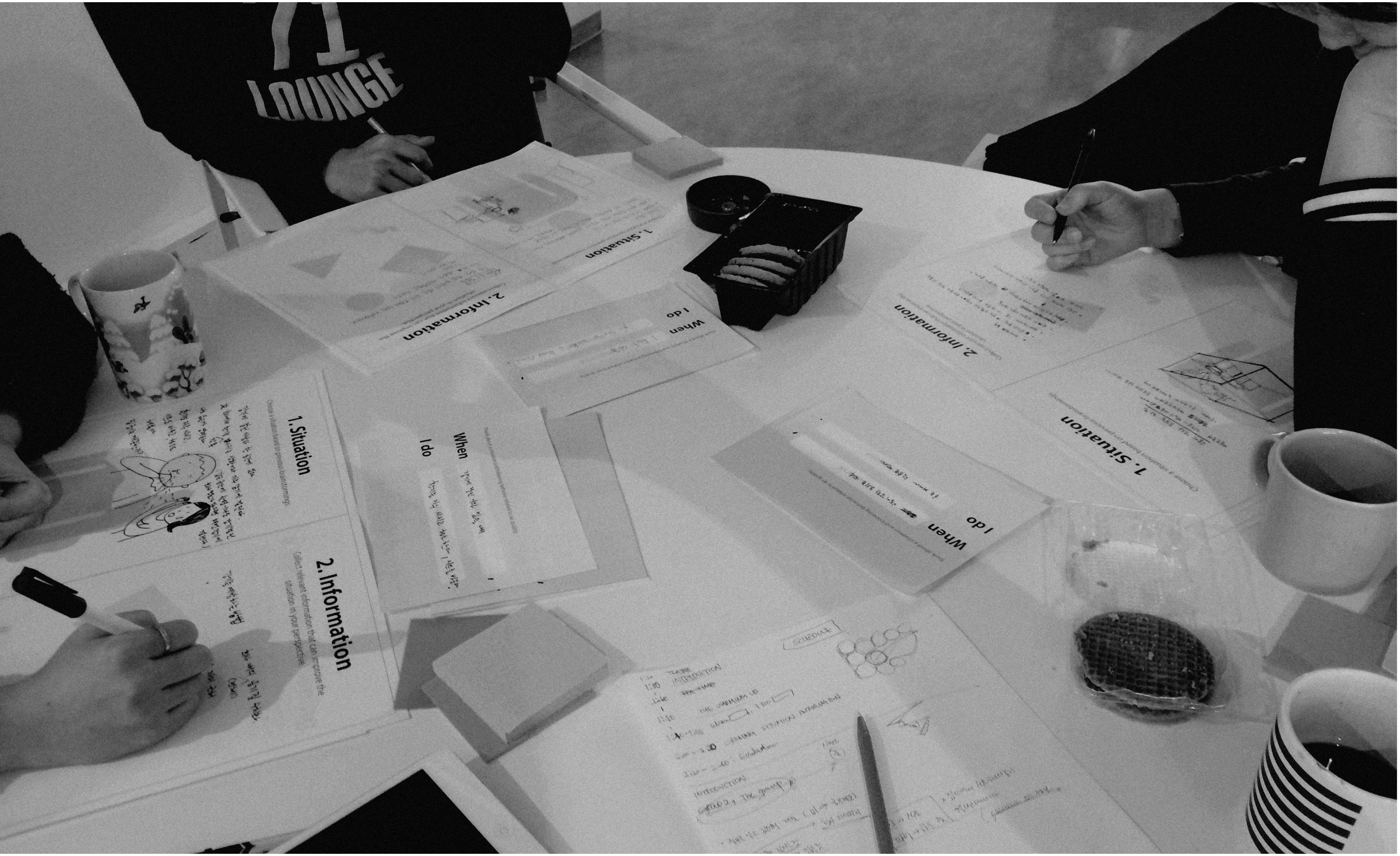


Figure 8: <Co-Design workshop>

In order to find answers of the main research question (See 1.1 Objectives and a Research Question), the study firstly built a hypothesis and categorize user groups based on it (See 3.1 Hypothesis). Acquired knowledge from desk research was also applied to user research; an Online survey, user interviews and Co-Design workshops, by specifically focusing on users' diverse motivation levels in the context of air quality. During the study, the scope of research was narrowed down to User Group 2 (See Table 3).

As a consequence of the user research, the study identified that 'awareness' is a core element formulating one's motivation. It also found auxiliary elements: experience, information and context, to support increasing awareness and motivation of people. Based on the finding, an adapted behavior model from Fogg (2009) was created. (See 3.4.2.2 Findings and Insights; 3.4.4 The Synthesis of Research Findings and Insights)

In addition, the research question and hypothesis were conclusively justified throughout the user research. The research results clearly showed that people have differences in accepting visual languages and changing their behaviors depending on their motivation levels. In detail, for User Group 2, simple and understandable visual stimulus evoking emotional interactions were regarded as more persuasive to bring changes in their behavior in contrast with User Group 3 and 4. (See 3.4.4 The Synthesis of Research Findings and Insights).

—

3.1 HYPOTHESIS

Based on the foundations from the desk research, the user research is aimed at focusing on empirical investigations to get useful findings and insights regarding people's motivations towards air quality. To bring concrete results from the user research, it built a hypothesis;

'depending on the users' motivation levels, the ways of stimulating behavior change in the context of air quality would be different.'

When it comes to air quality, people seem to clearly have different motivation levels, i.e., some have not thought about the subject, some are somewhat interested; some strongly adhere to or already have expert knowledge of it. Those explicit differences between individuals probably need different approaches for persuading to change their behaviors.

Table 3 illustrates the hypothesis, and it divides user groups based on their anticipated motivation levels. Based on these initially classified user groups, the user research examined diverse aspects of motivation that people variously have.

—

3.2 RESEARCH OVERVIEW

User Group 1	*User Group 2*	*User Group 3*	*User Group 4*
Unmotivated	**Somewhat motivated**	**Motivated enough**	**Motivated enough - Special health issues**
• Unawareness • People do not have enough motivation to use air purifier. • People do not know the relationship between air and health condition.	• Not enough awareness • People have somewhat motivation to change their behavior. • Insufficiently knowing the clear relationship between air and health condition.	• Enough awareness and motivation • Being aware the relationship between air and health condition well. • Behaving well to improve their air quality.	• Enough awareness • Strong motivation to use air purifier • Willing to change behaviors to improve air quality. • Diverse contextual differences including special health issues: asthma, respiratory diseases, etc.

Table 3: <User groups>

Based on the hypothesis categorizing four different user groups through their motivation levels, the user research investigating the motivation of users regarding air quality was conducted. To figure out the differences of motivations amongst user groups, three research activities: Online surveys, user interviews and Co-Design workshops, were implemented with 116 participants who have different nationalities and backgrounds of experiencing air quality.

To get core insights, the results of the three research activities were distilled several times through a coding process on each stage (Saldana, 2009) and the final insights used as the foundation of the case study (See 4. Case Study: Philips Smart Air Purifier).

—

3.3 RESEARCH METHODS AND SCOPE

Research methods included an Online survey with questionnaires, user interviews and Co-Design workshops. The Online survey was shared via diverse social media, and it aimed to get general understanding of people's different motivations and their contextual differences based on it. User interviews more focused on User Group 2 & 3, and it used more qualitative approaches to understand interviewees' motivations and behaviors in the context of air quality. Co-Design workshops invited people from User Group 2, encouraged them to participate in creation activities (See Figure 9).

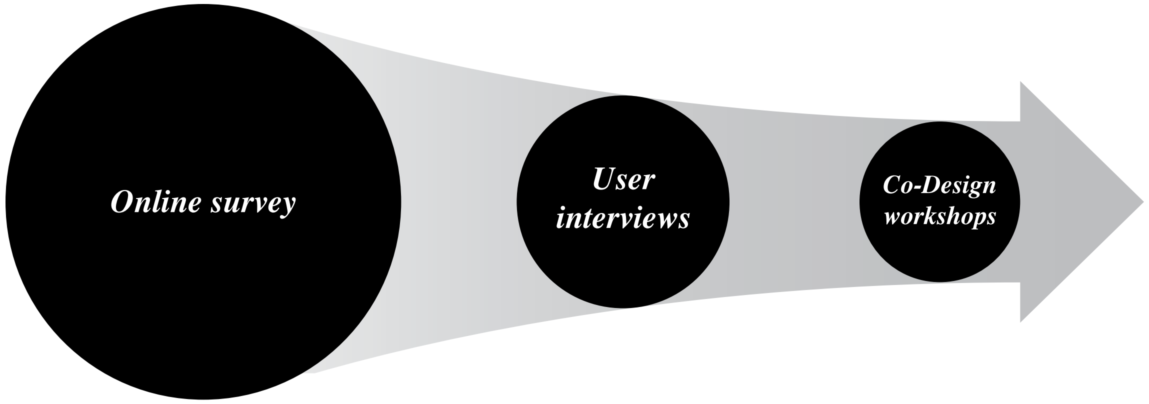


Figure 9: <Research methods and scope>

With the limitation of time, all user groups could not be deeply investigated. For this reason, the user research started with Online surveys for all groups then progressed to Co-Design workshops for a specific target group – User Group 2. This approach came from speculations that User Group 2 would have the most of general users, and accessibility to the target group for conducting research was relatively high in comparison with other user groups. Furthermore, the group was regarded as the group with the highest potential for behavior change through interventions, since they already have a certain amount of motivation, but not behaving actively for having clean air. Additionally, the general knowledge of air quality in User Group 2 (See 3.1 Hypothesis) also seemed to mostly dependent on feelings or assumptions, which could be more easily altered by delivering effective interventions.

—

3.4 RESEARCH ACTIVITIES

—

3.4.1 ONLINE SURVEY

The Online survey (N=104) was conducted within 20 days from the 23rd of March in 2016 to 12th of April in 2016 with various participants who were from 16 different countries with a 20-49 age range. The survey link was shared in various social media including Facebook, Twitter and LinkedIn, and some of participants were selected by convenience sampling (Castillo, 2009)

The purposes of conducting Online surveys as the first research step were to initially examine assumptions from the hypothesis and to get general interpretations of how people accept information and behave with air quality in all user groups. Meanwhile, it is also purposed to define the desirable information that people prefer to have depending on their motivation levels.

—

3.4.1.1 QUESTIONS

INTRODUCTORY QUESTIONS

To identify different user groups according to their motivation levels, participants had to respond to introductory questions that follow a logic map, which guides them through an anticipated user group based on their answers (See Appendix 1 < Introductory questions for identifying user groups>).

UNIVERSAL QUESTIONS

Participants who were categorized in a user group, had questions asking one's or any family member's health vulnerabilities, environmental contexts, usual behaviors for improving air quality, desirable information and the anticipated impact of delivered intriguing information (See Appendix 2 <Questions for Online survey>).

—

3.4.1.2 FINDINGS AND INSIGHTS

Total number of participants was 104 who had different nationalities: South Korean, Finnish, American and so on. The percentage of male and female participants recorded 42% and 58% individually. The numbers of classified participants in each group through introductory questions were:

User Group 1: 9
User Group 2: 20
User Group 3: 61
User Group 4: 14

As the result shows, User Group 3 recorded 61 participants, while User Group 2 only remained 20 people. This result was contradictory with an assumption; User Group 2 would have the most number of common users. Nevertheless, there was a possibility that it came from wrongly designed introductory questions that could have misled users. To identify this issue more clearly, qualitative investigations: user interviews and Co-Design workshops, were conducted with 12 participants in the following research activities.

Around 36% of participants had the experience of using air purifiers. Among them, 41% of users responded that they stopped using air purifiers, since it was hard to recognize the long term effects of using air purifiers. Amongst the people who already had experiences using air purifiers, 71% of participants used the product to clean air, and 11% of people used it for the health of their babies or children.

HEALTH ISSUES AND ENVIRONMENTAL CONTEXTS

78% of people or their family members in User group 4 showed that they have health issues related to air quality (See Figure 10). With a question asking if they live in a location in which has bad air quality, 77% of people in User Group 4 answered positively.

When these two answers were compared together, it showed a relationship between the air quality from the environmental contexts and the health issues regarding air quality. It illustrates a tendency wherein people who live in locations having bad air quality would have more health issues, or they would have more sensitivity to bad air quality due to their health issues.

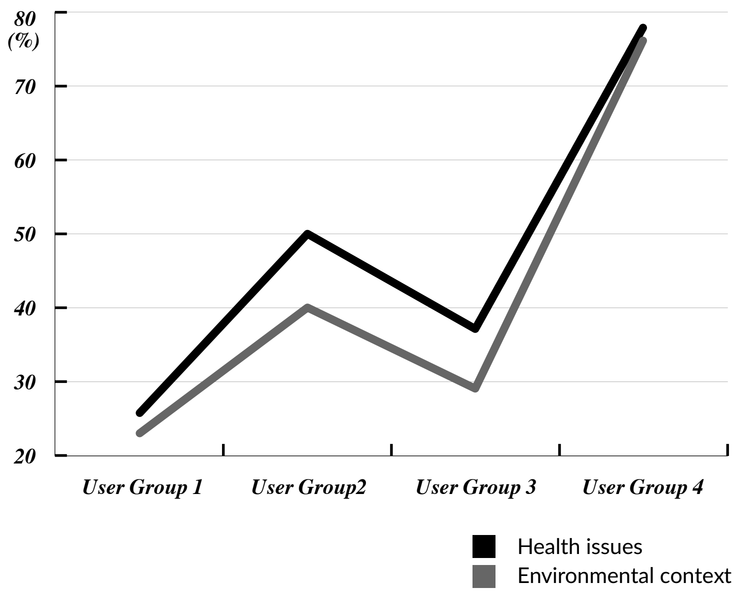


Figure 10: <Health issues and environmental contexts>

FREQUENCY AND TIMING OF VENTILATION, AND ELEMENTS MAKING PEOPLE FEEL THAT AIR IS STALE

The rate of ventilation per day was gradually increased from User Group 1 to User Group 4 (See Figure 11). Around 10% of people in User Group 1 ventilates air more than once every day, but User Group 4 recorded nearly 45% of positive responses, which can be understood as a difference of sensitivity or motivation of individuals within the user groups.

The timing of ventilation had similar results between different user groups (See Figure 12). 25% of people open windows or ventilates air during the morning time, and 13% of people do the same at night time before sleeping. People cooking and feeling stale demonstrates 11.6 % individually.

Among various reasons for having bad air quality, 'Haven't done

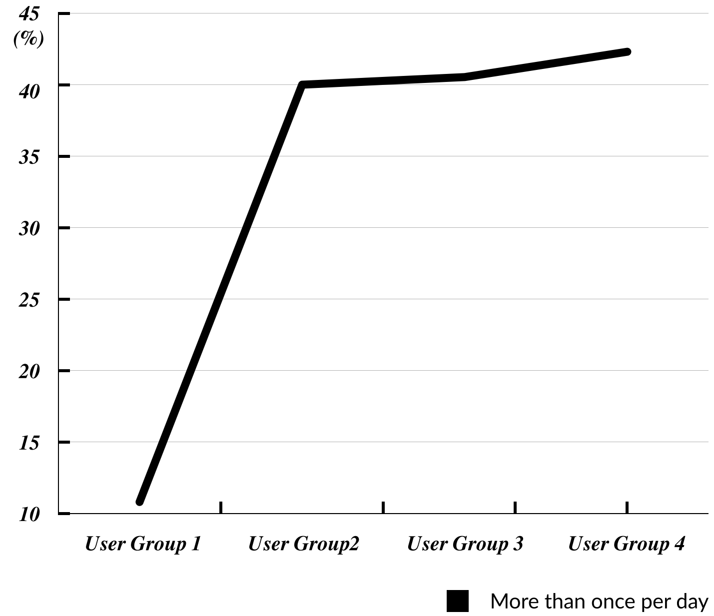


Figure 11: <Frequency of ventilation>

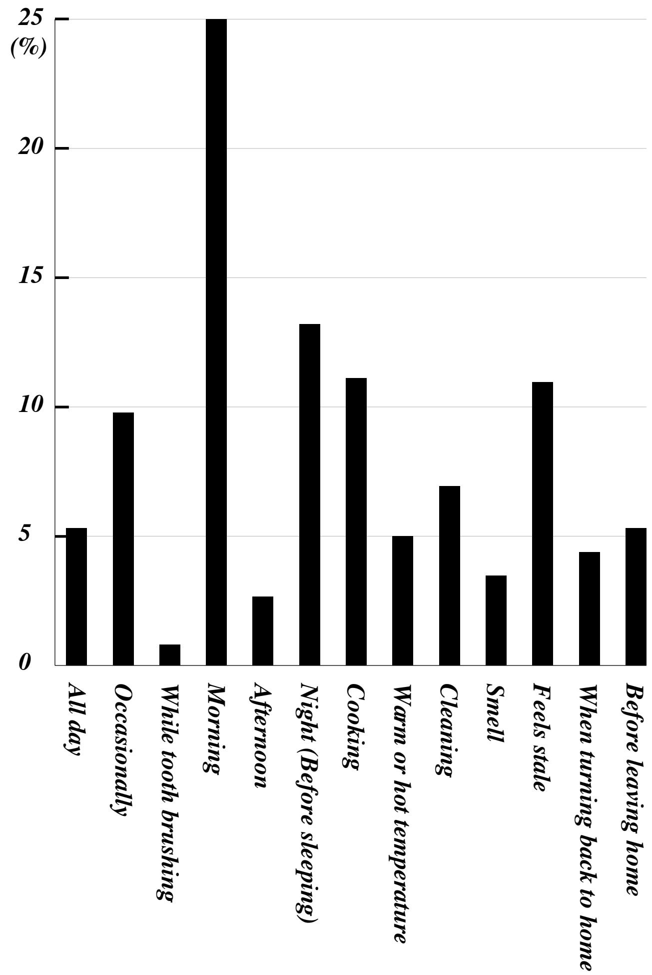


Figure 12: <Timing of ventilation>

ventilation for a while' was selected as the highest at 17.8% (See Figure 13). 'Smell' and 'Visible dust' followed with 16.8% and 15.8% respectively. 9.9% of responses were 'Cleaning', and 'Cooking' was at 8.91%.

The result showed that opening windows and ventilating air as the most common behavior that people commonly do to improve indoor air quality. However, considering that outdoor air quality varies based on environmental contexts – people assume that air quality would be good in the morning, but it is not true depending on the location, e.g., a house beside heavy traffic in the morning time, the timing of opening windows is crucial. Interventions can trigger users to open windows at the right time by providing correct real-time data.

The behavior of 'opening windows' can be a challenge for someone, especially for people in User Group 1 indicating only 10% of people ventilate air more than once per day. Due to this reason, this behavior was selected as a possible behavior challenge for the Case Study.

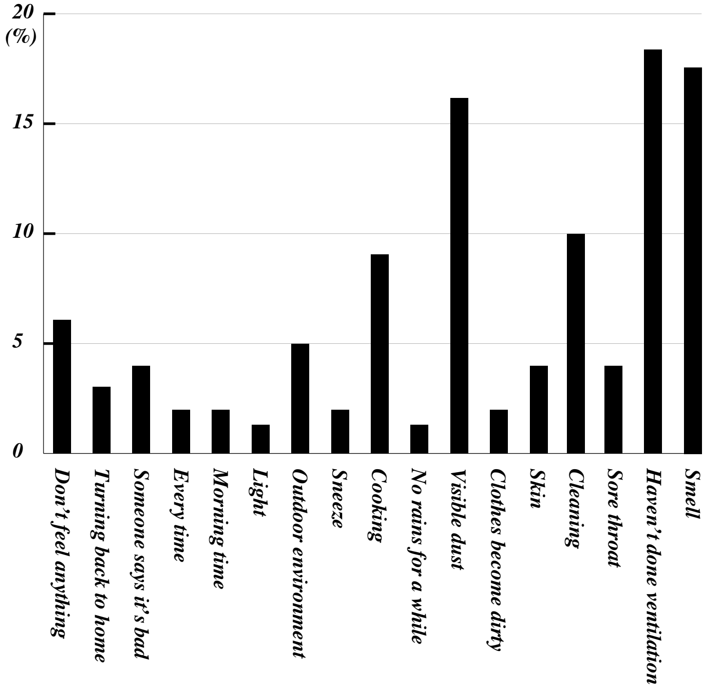


Figure 13: <Elements making people feel air is stale>

THE CHANGES OF MOTIVATION AND DESIRABLE INFORMATION

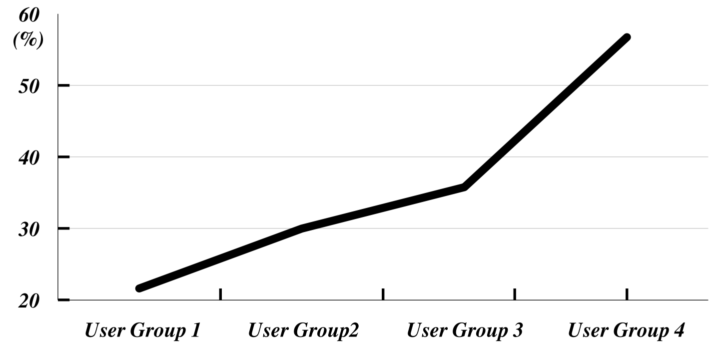


Figure 14: <The changes of motivation after accepting an information>

After accepting intriguing information that could bring different perspectives of indoor air quality, i.e., indoor air quality is generally 2-5 times worse than outdoor air quality regardless of its location (EPA, 2013), individuals in different user groups showed contrasting results (See Figure 14). In detail, participants in User Group 4 showed approximately 58% of positive answers for changing their behaviors; most of the responses from user groups were that they would do ventilation more often after accepting the information. On the contrary, User Group 1 merely recorded around 22%.

Among the desirable information, the current state of indoor air quality, the ways of improving house air quality, and the possible causes of bad air quality in house were universally preferable information in all groups (See Figure 15).

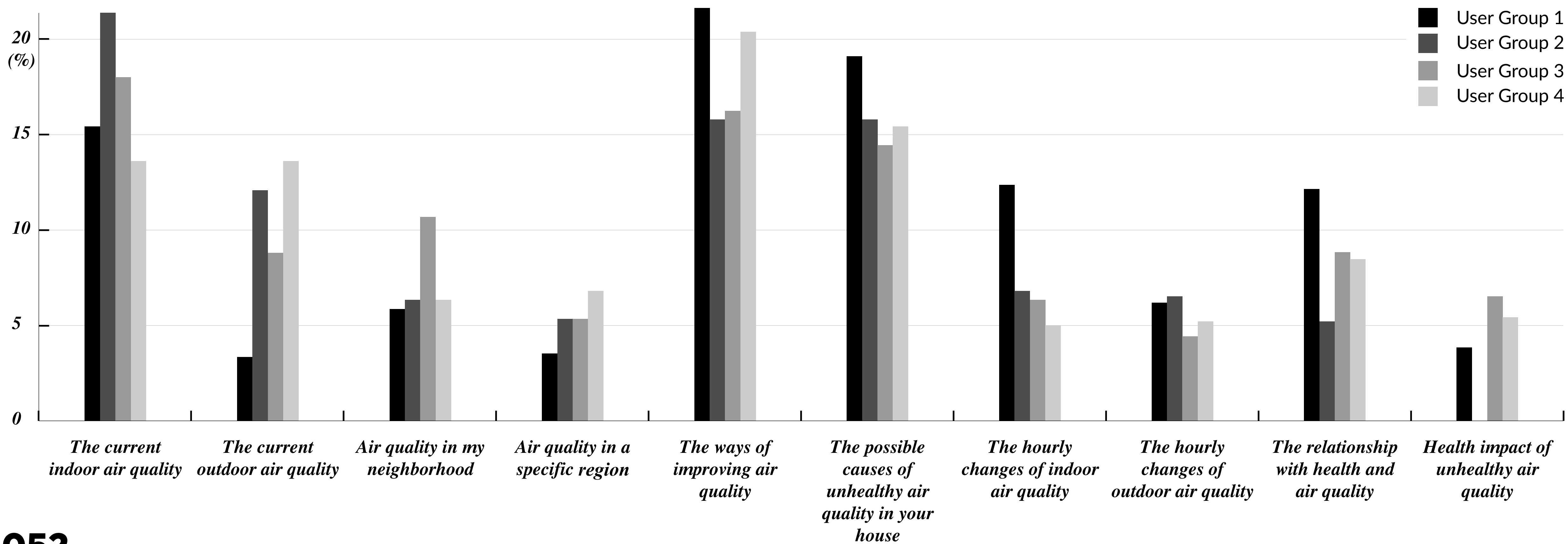


Figure 15: <Desirable information>

Overall, the willingness of changing behavior – motivation, after accepting information was different depending on groups, but the core information is that what people desired to know was similar.

TRAITS FROM DIFFERENT ENVIRONMENTAL CONTEXTS

From the responses of participants who have different environmental backgrounds, a gap between Westerners and Asians was founded.

First of all, the most experiences of using air purifiers happened in Asian contexts: South Korea, China, Singapore, Taiwan and more. People who live in European countries mostly do not have any experience in using air purifiers in their life, but they were more sensitive to various health issues: allergies, skin sensitivities to dusty air or humidity, rhinitis, asthma, and so on. This means that the needs of users who live in other environmental contexts are likely different. The main purpose of using air purifiers in Asian contexts was to purify air due to unhealthy air quality such as yellow dust and haze. However, in the European contexts which do not have serious air quality issues, they utilize the product for their own health issues that they already have.

Secondly, many Finnish respondents strongly believed that air quality is very good in the country, and they did not regard it as a main issue in their daily lives. However, it is also true that Finland has a high rate of allergic diseases due to unhealthy indoor air quality like many other western countries (Haahtela et al., 2008, p. 634).

These results demonstrate that there are needs of a universal design for both of Westerners and Asians who have different needs: purifying air quality caused by air pollution and preventing various related health issues.

—

3.4.2 USER INTERVIEWS

User interviews have been conducted with 6 participants who already had experiences of using air purifiers in different countries, i.e., Singapore, China, South Korea and Finland. They were identified in User Group 2 and 3 with introductory interviews asking how do they think of air in general and how do they behave to have clean air in their daily lives. To avoid a mistake that was happened in the previous Online survey (See 3.4.1.2 Findings and Insights), the study qualitatively interviewed participants.

The interviewees who already participated in the Online survey (Castillo, 2009) were selected by convenience and the interviews were conducted face-to-face or through Skype calls for approximately an hour and half.

The purposes of having user interviews were:

- *Proving the hypothesis (See 3.1 Hypothesis).*
- *Identifying the core needs of people in User Groups 2 and 3*
- *Understanding the users' motivations based on their contexts: physical, personal, cultural and environmental context (See Table 2)*
- *Finding the correlation between awareness and motivation.*
- *Getting the general interpretation of people's experiences in the using of air purifiers.*

—

3.4.2.1 QUESTIONS

The questions were primarily prepared for asking the users' contexts, awareness and motivations of using air purifiers (See Appendix 3: Questions for user interviews). Each category of questions had 3 to 8 questions and was designed to minimize the assumption of the interviewer (Turner, 2010).

—

3.4.2.2 FINDINGS AND INSIGHTS

The contents of user interviews were collected and analyzed through a coding method that captures hidden keywords amongst the users' data (Saldana, 2009). The keywords from the analysis consist of invisibility of air, motivation and awareness: experience, context, information, and alerts.

INVISIBILITY OF AIR

One of the traits of air: invisibility makes users unable to recognize the air quality correctly. In fact, even a day with the clean sky and dazzling sunshine, actual air quality in a location could be unhealthy (Evans and Jacobs, 1981). Most answers from the interviews showed that people usually assume air quality of a space or alternatively check other visible elements: dust and smoke, to recognize indoor and outdoor air quality. When people can see visible elements related to air, it delivers negative meanings to them in many cases. For example, when one notices floating dust in the air, it could generate the image of breathing the dust without filtration. Through the image, the person would feel that the air is dirty or unhealthy.

However, there were exceptions wherein visible elements could positively work based on contexts. For instance, when people perceive collected dust on filters in an air purifier, it initially brings negative feelings to viewers. However, there was a tendency that users regarded it as an effective performance of the product at the same time. The reason why people conflictingly understood it is that they regard the collected dust as an effective performance of the product, since they could see the filtered dust through their eyes. In this case, dust in the air filter can be as a visual medium as to how much dust was in a space, and how much the product performed successfully.

In a nutshell, visible elements could help users understand the invisible air quality, and as an example, dust can convey both of positive and negative meanings.

AWARENESS AND MOTIVATION

One of the findings from user interviews is that awareness is a basis for building a motivation. Namely, before having a motivation for having clean air, people need to be aware of what is currently happening in the air, and what the possible consequences of it are. If one does not recognize the situation at that moment and the effects of it, they would not have the opportunity to develop their motivation on a subject (See 2.1.2.1 Motivation; 2.1.3.1 Unawareness). From the understanding of this relation, the study found three elements for developing awareness and motivation: experience, context and information, from the result of user interviews.

EXPERIENCE

Feeling and experiencing air is a crucial way of understanding air quality in a space. It works with the automatic system of human brain, which is fast, unconscious and effortless (See Table 1). Interviewees showed a tendency that they commonly feel and experience air of a space rather than rationally understand it. However, most visual indications of air quality by products were not sufficient to deliver feelings and experiences of air; it uses texts or numbers, and people need to understand it through their reflective system. To consider one of the core purposes of the air quality indication: helping users accept the information quickly, the visual intervention can embrace emotional and experiential stimulus for the efficiency of the communication.

INFORMATION

The result of user interviews showed that individuals who have different motivation levels need different information. It manifests that the same information should not be provided for everyone, it should be tailored based on their motivation. For example, interviewees who were in User Group 2 mostly demanded simple information for their basic needs, but people in User Group 3 needed a more detailed information.

Not only was the quantity of the information, but also the contents of the information demanded differently. In case of User Group 2, they answered to basic information: current indoor and outdoor quality, would be simply enough. On the other hand, one of the users in User Group 3 who has a baby wished to have a much more varied air information, i.e., health effects of unhealthy air quality on her baby and changes of air quality on a daily basis.

CONTEXT

The interview results showed that the ways of delivering information stimulating people's awareness and motivation could be differed based on contextual differences. As the previous desk research defined Context (See 2.1.1 Context), the findings were categorized into four sections: physical, personal, social and cultural context.

First of all, people who lived or are living in Asian contexts, had clear needs of clean air. For example, people who live in South Korea and Japan have problems of the yellow sand (Asian dust) from the Gobi Desert and Loess plateau in Northern China every spring season (In and Park, 2002). Particularly during the season, it makes people behave differently; people avoid doing outdoor activities or they wear masks.

Secondly, personal context made strong effects on people's motivation. For example, one of the interviewees described that she had a very high motivation for having clean air when it to infant. She told that she had not considered the air quality as a main issue in her life, but everything changed after having the baby.

In terms of social context, most of the participants from collectivist countries showed a tendency of thinking in terms of 'we', which naturally brings group behaviors and avoid exceptional behaviors which break the harmony of the group (Khaled et al., 2006, p. 11). For example, participants felt the pressure for wearing masks when they saw other people do it.

Lastly, cultural context was also influential to people's motivations and behaviors. For example, people in Finland are not likely to wear a mask in a public space even when they know the air quality is somewhat unhealthy. However, in South Korea or Japan, people do not usually hesitate wearing a mask when the air quality is bad or even when they have symptoms of light flu.

ALERTS AND TIMING

As people's daily lives are getting more connected to the Internet, digital stress from emails, texts, social media, chat rooms and forums has become a rising issue (Salvetti, 2016). In this sense, most of the interviewees answered that mobile notifications generally distract them, and feel annoyed.

However, there were exceptional situations when interviewees want to get notifications. For instance, when air quality is unhealthy, they want to know what is happening in the place. The information for alerting unhealthy air quality is directly connected with their health, so that they can do certain reactions, e.g., ventilating, removing pollutants or escaping the place. Furthermore, one's motivation level also influences in getting alerted, i.e., when one's motivation is high enough, the person would want to get alerts about clean air quality. Above all, the timing of alerting is strongly based on one's context. An alert can be important information in a situation, but the same alert can be simply regarded as a distraction in a different situation.

Another finding from getting alerts was that it needs to be delivered not only as information, but also as alternatives, which provide possible solutions that users can do for a problematic situation, e.g., wear a mask, close windows, run an air purifier and so on. The result of the Online survey also showed a similar finding (See 3.4.1.2 The Changes of Motivation and Desirable Information). Most of the air indicators just deliver the information of a current situation about air quality, but it does not suggest any solution to it. When users do not know how to react to the situation, changing behaviors would be hard to succeed.

—

3.4.3 CO-DESIGN WORKSHOPS

A Co-Design activity is an event that invites people in a design development process (Sanders and Stappers, 2008, p. 6). For the user research, the workshops were conducted two times with 6 participants from User Group 2. Each workshop planned for two hours with three participants and one facilitator. For the efficiency of managing the workshops, participants were invited amongst people who were already joined the Online survey or user interviews of this project.

The aims of conducing Co-Design workshops were:

- *Proving the research hypothesis (See 3.1 Hypothesis)*
- *Having a deeper understanding of an individuals' needs in User Group 2 (See 3.3 Research Methods and Scope)*
- *Finding insights about the timing of triggers, desirable information and possible behaviors.*
- *Evaluating the initial design ideas and getting quick feedbacks*

—

3.4.3.1 TASKS FOR THE WORKSHOPS

The workshops were consisted of four activities: mood board, behavior cards, collecting information and visualization and evaluating initial ideas. To bring successful outcomes through the workshops, diverse materials for each workshop activity were prepared.

MOOD BOARD

As the first activity of the workshops, a randomly selected series of pictures and a question; 'what makes you feel that air is fresh or bad?', were provided to participants. They collected positive and negative images on their own perspectives, and shared it with others (See Figure 16).

This activity was a warming up phase bringing the topic into the workshop and making participants feel free to express their own thoughts regarding air quality.

BEHAVIOR CARDS

As the second activity, behavior cards asking how they behave when they confront with a certain situation related to air, were delivered (See Figure 17). The card simply gave 'When' and 'I do' and asks participants to freely fill blanks with their own experiences. Throughout this activity, users' behaviors and the timing of it in different contexts could be figured out.

The results of the behavior cards were also shared with other participants, and one of the cards was used for the next activity: collecting information and visualization.

COLLECTING INFORMATION AND VISUALIZATION

Based on the behavior cards, participants were asked to select one and develop it, i.e., defining a context, collecting information, making possible behavior lists and creating a visualization to trigger the behaviors (See Figure 18). By doing so, participants could independently create what information could possibly make a behavior change, and how the information could be visualized and delivered in an opportune moment. The results of this activity were also shared and discussed with other participants.

EVALUATION FOR INITIAL IDEAS

The last activity of the workshops, participants evaluated initial design ideas; 17 different rough concept images containing diverse visual elements: colors, images, numbers, emoticons and graphs, were prepared to be evaluated (See Figure 19). Participants briefly commented on each concept ideas and evaluated the anticipated effects of the provided visual elements.

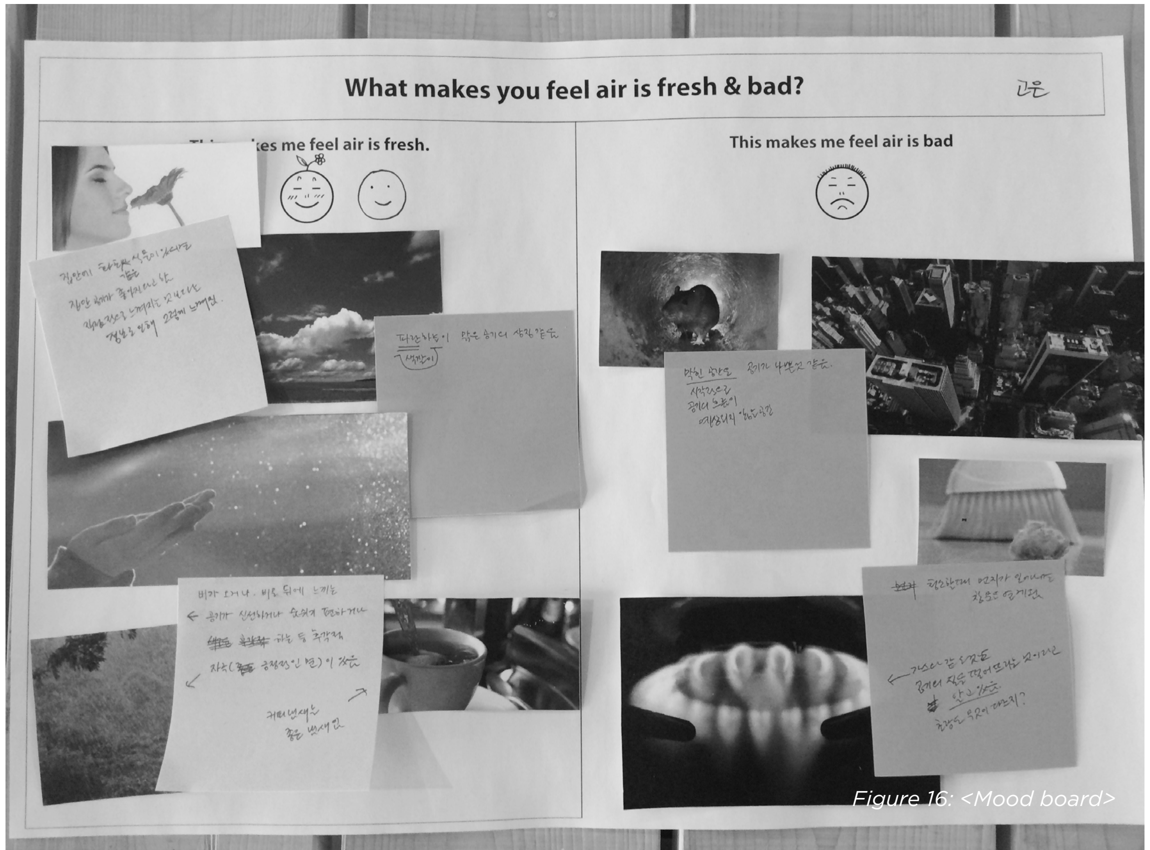


Figure 16: <Mood board>

Figure 17: <Behavior cards>

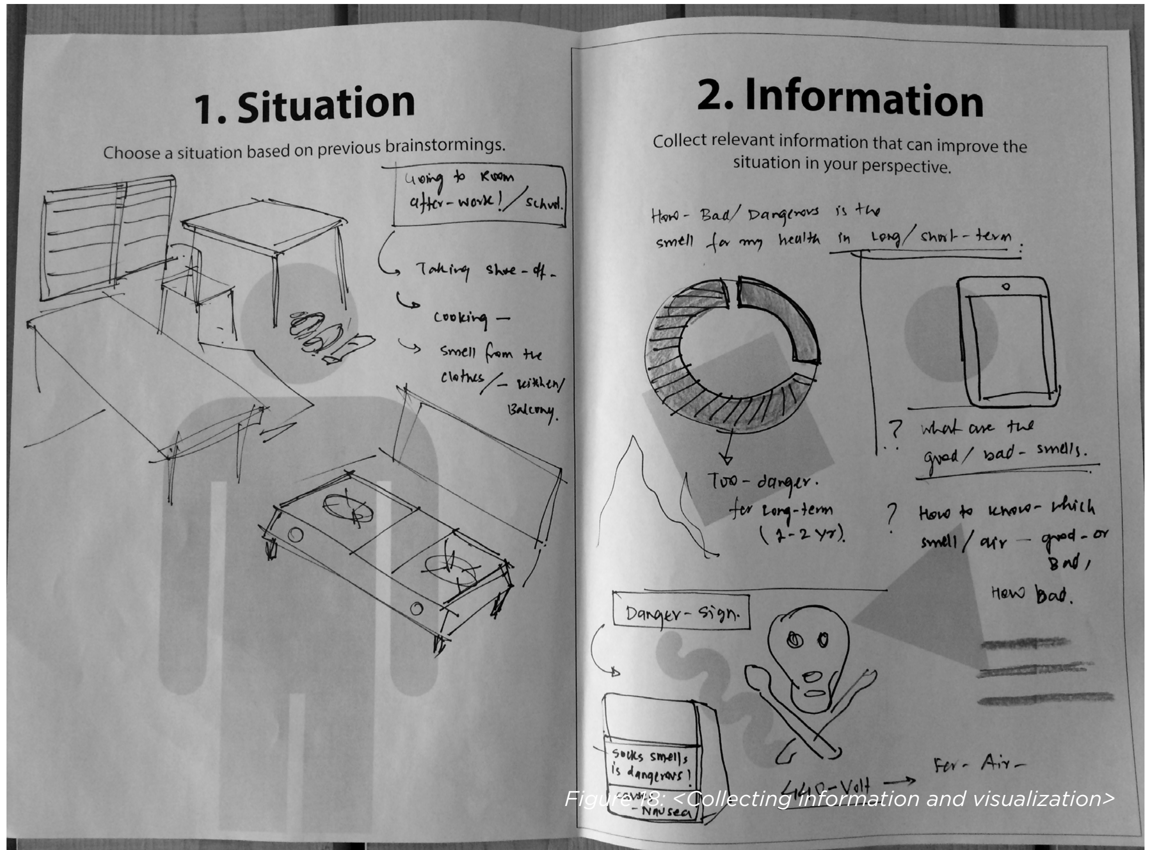


Figure 18: <Collecting information and visualization>

Figure 19: <Evaluation for initial ideas>

3.4.3.2 FINDINGS AND INSIGHTS

The Co-Design workshops brought numerous ideas from users' perspectives. Many parts of the findings showed similar results from previous researches, e.g., images or colors give more direct understandings rather than numbers and graphs, and personalized information and alerts are necessary (See 3.4.2.2 Findings and insights).

To evaluate the results of the workshops, the study used coding analysis in categorizing similar comments that were closely connected with each other and finding keywords from it (Saldana, 2009).

PERSONALIZATION REFLECTING CONTEXTUAL DIFFERENCES

As previous literature and user research showed, context is an essential element for building behavior change (See 2.1.1 Context; 3.4.2.2 Context). The results of the workshop also manifested that the information reflecting users' contextual differences are highly likely to increase the motivation of users, and it could be a basis of one's behavior change.

One of the practical ideas to support the finding – delivering context-relevant information, was that a system can provide different default options depending on the contexts of users. For example, during the onboarding process – downloading an application and registering personal information before using the product, the system can ask or figure out the user's contextual differences, i.e., location, country, health issue, vulnerability of family members and so on, and reflect it into a default option for the person. Throughout this personalizing process, users could have the best starting point reflecting their contextual traits that could ultimately increase the awareness and motivation of people (See 4.4.4.1 Concept Design).

EXPERIENCING AIR AND UNDERSTANDING INFORMATION

The results of the workshops showed a tendency that when users recognize air quality, it is mainly divided two steps.

The first step is experiencing the invisible air through visual elements – similar result from the user interviews (See 3.4.2.2 Invisibility of air). Most of the responses from the participants demonstrated that they would be able to perceive invisible air quality through visible elements, e.g., dust, smoke, color and so on. These elements do not necessarily demand effort from users to make them understand air quality. In other words, the visible elements could be instantly and naturally understood by perceivers without consideration, which has known to be as one of the traits of sensory symbols (See 2.1.1 Information). For example, when people see streaming water, rain in a forest, the clear sky, stars at midnight, moving leaves through the breeze and opened windows, they would feel the air is clean in those places.

The second step of perceiving air quality, participants showed a tendency that they understand a situation more precisely through detailed information, e.g., air quality in Shanghai is P.M 72. In this phase, arbitrary symbols convey the information, which are insufficient to deliver an experience or feeling of air quality, but it effectively brings correct information that people can interpret. People need more time and effort to understand the information, but it illustrates accurate data, so that people can rationally understand the facts happening surrounding them.

POSITIVE AND NEGATIVE

Sensory symbols are effective in bringing certain feelings and emotional interactions to users (See 2.2.2.3 Emotion from Perception). During the workshops, participants discussed elements that would bring positive and negative images regarding air quality for them.

Positive images consisted of blue and green colors, trees, smiling emoticons, clean sky, rains, cold temperature, stars, opened windows, and so on. Negative images included red colors, factitious scent, dust, exhaust, closed space, smoke and more. The elements bringing negative images have a strong energy for arousing people's attention instantly (See 2.1.2.1 Trigger). For example, a red color gives a fast estimation of the current air quality; air quality is not good. Participants answered that they would feel anxious and nervous if they see the red color on an air indicator. It has advantages rising users' motivation quickly and highly likely making them behave, but it also has moral issues wherein interventions would strongly arouse negative feelings within individuals (Fogg, 2003, pp. 211–239) (See 2.1.2.1 External and Internal Trigger).

BEHAVIOR SUGGESTIONS

Throughout the workshop activities, possible behavior lists had been defined through the users' perspectives.

- *Avoiding polluted air*
- *Wearing a mask*
- *Ventilating air*
- *Finding pollutants and removing it*
- *Using devices cleaning air, e.g., air purifier*
- *Growing plants*
- *Not doing behaviors that could make unhealthy air quality, e.g., cooking without ventilation, smoking inside and so on.*

Those behaviors are actions that users can do to improve the air quality or prevent being exposed to unhealthy air quality. Throughout this behavior list, interventions could suggest alternative behaviors to users when a situation of negative air quality occurs. By accepting the behavior suggestion, users could know not only the status of air, but also the ways of resolving the situation.

The initial defined behavior lists had been developed for a behavior challenge during the Case study (See 4.4.6.1 Selected Target Behaviors).

—

3.4.4 THE SYNTHESIS OF RESEARCH FINDINGS AND INSIGHTS

To categorize commonalities among all findings and insights from user research activities, all results had been analyzed together through a coding analysis for three times in total (Saldana, 2009). Throughout this analysis, the project could have arranged keywords: experience, information and context, which are connected with motivation and awareness of a behavior change, and it had been used as the cornerstone of the case study.

FINDINGS FOR HYPOTHESIS AND RESEARCH QUESTION

The hypothesis; 'depending on the users' motivation levels, the ways of stimulating behavior change in the context of air quality would be different', was conclusively proved; visual interventions aiming to effectively change behaviors of users would reflect their motivational levels in the context of air quality. As findings and insights from the user research showed, people have clear differences in accepting visual languages and changing their behaviors depending on their motivation levels, which are strongly influenced by their contextual differences (See 3.4.2.2 Findings and Insights; 3.4.3.2 Findings and Insights).

In detail, individuals in User Group 2 demanded simple information that can be understood without much consideration for their basic needs, i.e., the current air quality and ways of improving the air quality. However, people in User Group 3 needed a more detailed and tailored information since they have specific needs due to their contextual traits, i.e., sensitive family members, health issues, and unhealthy air environments. In other words, interventions through simplified sensory visuals stimulating the automatic system would be more persuasive for individuals in User Group 2 (See 2.1.1 Information; 2.2.2.2 Sensory Versus Arbitrary Symbols). For them, conventional arbitrary symbols: long texts, numbers or graphs, are less persuasive, because they are not motivated to accept much detailed information. In the case of people in User Group 3, they are willing to have a more detailed information rather than getting only simple and basic one, since their motivation is high enough to accept complex information. In a

nutshell, the ways of stimulating behavior change should reflect the users' motivational levels in the context of air quality.

Throughout the proved hypothesis, research question; 'how visual communication would influence the behaviors of users who are differently motivated to improve air quality', was also answered.

First of all, the study identified in delivering visual communication increasing the awareness of users is essential to develop their motivational levels. As being aware of a subject is the first step to change (Brewer and Rimer, 2008, p. 155; Prochaska et al., 2008, p. 101), interventions can deliver visuals stimulating the users' awareness to increase their motivational levels, which ultimately influences their behavior changes. Especially, individuals in User Group 2 have relatively less awareness and motivation regarding air quality in comparison with people from User Group 3 and 4, developing awareness is more essential to change their behaviors.

Second, the study found three auxiliary elements: experience, information and context, which can support to increase the awareness and motivation of users (See 3.4.2.2 Awareness and Motivation). In detail, delivering the experience of different air qualities, providing the right information for the right users and contextualizing the functions and information for different individuals, are important to increase the awareness and motivation of users in the context of air quality. The study determined the ways of actualizing these three elements in a more concrete way: visualizing air, layering information and providing personalization and contextualization. More details regarding these will be illustrated in following sections (See 3.4.4 How to Enhance Experience: Visualizing Air; How to Enhance Information: Layering Information; How to Enhance Context: Personalization and Contextualization)

ADAPTED BEHAVIOR MODEL

Fogg (2009)'s behavior model had been adapated as a core framework to understand people's behaviors during the user researches (See Figure 3). The degree of each element of the behavior model: motivation, ability (simplicity) and trigger, has to be proper enough to make a behavior change. The exact amount of each behavior element to satisfy the framework is uncertain, but it is clear that the more motivation, simplicity and trigger on the right timing, more behavior changes could happen.

Especially, for motivation, the results of the overall research showed that awareness could act as a foundation for building a motivation for behavior change (See 2.1.2.1 Motivation; 2.1.3.1 Unawareness; 3.4.2.2 Awareness and Motivation). Acknowledging things happening in one's surroundings would give basic interpretations of a subject, one could start to consider the meaning of it, and finally the person would initiate increasing her/his motivation for having desirable results.

In the case of ability (simplicity) and trigger, it must be developed by service providers; choice architects should deliver a product that has good usability, and it should trigger users on opportune moments.

On the contrary, motivation should be developed through users. In other words, interventions could provide various information to improve the users' motivation, but ultimately the target who of should enhance motivation are the users themselves. This is the reason why enhancing awareness and motivation was regarded as the biggest challenge on this study – there are also other arguments about this perspective wherein ability should be firstly developed instead of increasing motivation, since enhancing motivation is expensive and time consuming (Eyal, 2014, p. 80).

To support the awareness and motivation more concretely, the study adapted the ordinary behavior model (See Figure 3) by adding three elements that had been found from researches: experience, information and context (See 3.4.2.2 Awareness and Motivation). Figure 20 illustrates the adapted behavior model that illustrates the relationship of each element. By framing this behavior model, the study endeavored to build effective communication bringing emotional interactions through evoking experience and providing personalized information based on users' contextual differences, which would increase the users' awareness and motivation regarding air quality.

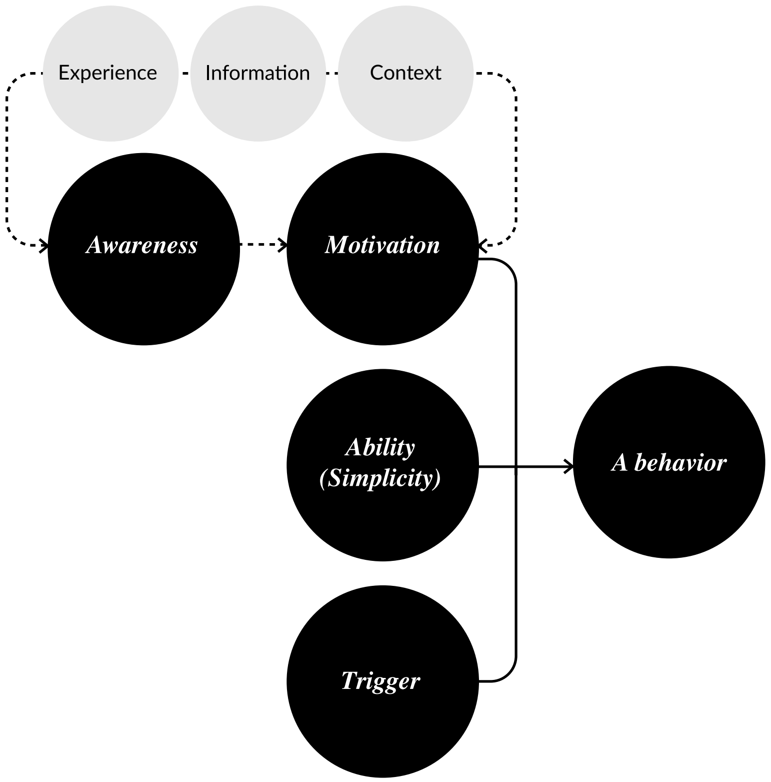


Figure 20: <Adapted behavior model (adapted from Fogg, 2009)>

HOW TO ENHANCE EXPERIENCE: VISUALIZING AIR

Delivering relevant experiences regarding air quality could give an instant and quick understanding of the air to users. As the user research results showed, the experience could be stimulated by sensory symbols that works with the automatic system of the human brain (See 3.4.2.2 Awareness and Motivation: Experience). The sensory symbols in this context include colors, emoticons, photographs and animation, which could bring an emotional interaction from users (See 2.2.2.3 Emotion from Perception).

One of the key findings that efficiently illustrate the air quality in an experiential way was visualizing the invisibility of air (See 3.4.2.2 Invisibility of Air). Many participants in different user research activities commonly mentioned that they could not exactly know the air quality without an air indicator, since it is invisible and odorless. Moreover, even if the air indicator delivers information through numbers or text, it does not efficiently give the feeling of clean or dirty air. For this reason, interventions that intended to enhance the users' experiences in feeling the air quality could visualize the status of the air through different sensory symbols. There are some examples that could be practically used in visual communication for the purpose: visualizing air quality through emoticons and colors, visualizing dust, visualizing the process of cleaning air and visualizing dust in the filters.

Firstly, emoticon and color could act as the representation of air quality at a moment. Emoticons indicating facial expressions of an entity's feeling or mood can efficiently work as an emotional communication tool (See 2.2.2.3 Emotion from perception). Just like emoticons, colors are also one of the effective sensory symbols that can deliver instant and fast messages. By combining these two visual stimulus together, a message that is intended to deliver an information with experience of air quality could induce emotional interactions of users. For example, when it comes to clean air quality, interventions could visualize a smiling emoticon with a blue color to represent the cleanliness of the air.

Secondly, the visualization of dust can also convey certain experiences to users. One of the repetitive responses from participants of each user research activity was that the invisibility of air makes people to insufficiently feel the air quality (See 3.4.2.2 Invisibility of air). The biggest difference was the fact that whether they could not see something in the air or not. When people recognize dust or smoke in the air, which is visible, it mostly delivers negative meanings; air is not clean or it feels stale. By utilizing this insight, interventions could show an air quality through animated dust in the air. For example, if the air quality in a place is unhealthy, one could see animated floating dust on their devices. When it comes to clean air, dust could be almost invisible, which does not contain any harmful substance.

Another example of visualizing dust is the illustration of a cleaning process, a user can have anticipated results of purifying air by visualization, and they can have experiences of hypothetical worlds that are regarded as the real one (Fogg, 2003, p. 61).

Visualizing collected dust on filters can also convey experiential messages. By illustrating dust on filters, people would initially accept a negative message; the filter is dirty. It delivers a message that they should immediately clean or change the filter to have clean air. At the same time, users could accept it as a feeling of satisfaction, since it represents the fact that the air purifier has effectively worked, since they could see the collected dust within the filters. This finding came from user interviews and Co-Design workshops, but it also has a possibility that the visual representation of collected dust could be understood in different ways other than the designer's intended purpose. For this reason, examination for proving this finding will be conducted on the upcoming design evaluation phase (See 4.4.8.2 Key Findings and Insights)

HOW TO ENHANCE INFORMATION: LAYERING INFORMATION

Context-relevant Information would help users increase their awareness and motivation of having clean air. In contrast with delivering the experience which evokes a certain emotion or feeling, information delivers a series of data that takes more time and effort to interpret (See 3.4.3.2 Experiencing Air and Understanding Information). The information could be formed through arbitrary symbols (See 2.1.1 Information), and people can accept it through their reflective systems (See 2.1.1 Human). Though, it needs to be rationally understood by users, so the approach delivering it to users should be different in comparison with evoking the experience of air. Because of these differences in purpose of evoking experience and delivering information, layering information is necessary.

The first layer of information can be filled with a simple, experiential and the most important data (See Figure 21). This layer of information could focus on the role of delivering experience through mainly sensory symbols. The second layer of information can represent a more detailed information on top of the first layer (See 3.4.3.2 Experiencing Air and Understanding Information). For example, when the first layer simply gives out information of the current air quality through emoticons and colors, then the second layer could illustrate the anticipated changes of air quality in the place with possible suggestions so people can behave to make air quality better. The last layer of information could be more detailed and personalized that it connects to one's health issues. It can show the possible health effects of bad air

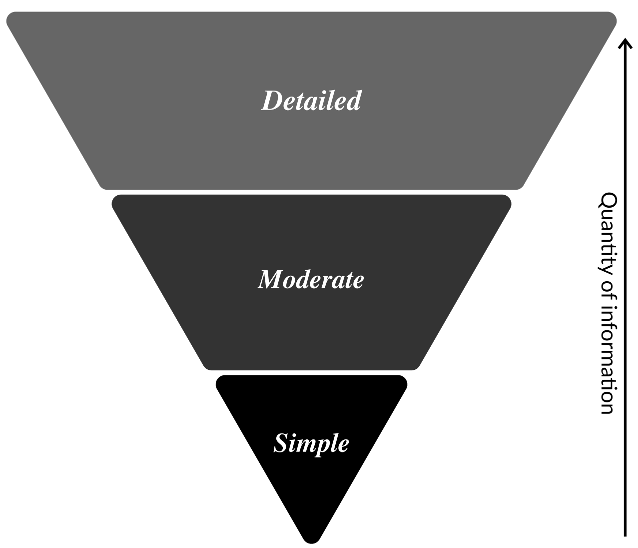


Figure 21: <Layers of information>

quality for an individual or even for their family members.

This segmented layers having different quantity and contents of information could be accessed by the users' interests, i.e., if one wants to simply check the current air quality, they do not necessarily need to see other detailed information, e.g., the historical changes of air quality in a location or expected health effects.

HOW TO SUPPORT CONTEXT: PERSONALIZATION AND CONTEXTUALIZATION

Reflecting the users' contextual differences including physical, personal, cultural and social situations is closely connected with the development of one's awareness and motivation. By having contextualized information, users could have more awareness, and it could naturally bring an increased motivation for having clean air. For example, if one has a baby in their house, a system could support it by giving detailed information about the relationship between air quality and baby's health issues. Through it, the person could understand the effects of bad air quality to their baby, and could have more motivation for making a cleaner environment to minimize the possibility of health issues for the baby.

To contextualize information to different users, a service should categorize the different users' groups who have various motivation levels. For example, the personalized and tailored information could be delivered throughout the on boarding process of an app. On this stage, users could input their personal information reflecting on their contexts, e.g., health issues, house size, vulnerability of family members and so on. Then, the service categorizes their groups based on the users' motivation levels and contextual uniqueness. By doing so, the system can provide a relevant default option and can help them to constantly develop their situations (See 3.4.3.2 Personalization Reflecting Contextual Differences).

The personalization reflecting on contexts can also support the distracting alert issues, which is differently accepted by users' motivation levels (See 3.4.2.2 Alerts and Timing). For example, for people who were categorized User Group 1 or 2, they can only have alerts when the air quality is unhealthy. On the contrary, individuals in User Group 3 or 4 can have more personalized alerts reflecting contextual traits such as allergy or air quality forecasting.

““When it comes to persuasion, experience makes a difference.”

-Fogg, 2002

4. CASE STUDY: PHILIPS SMART AIR PURIFIER

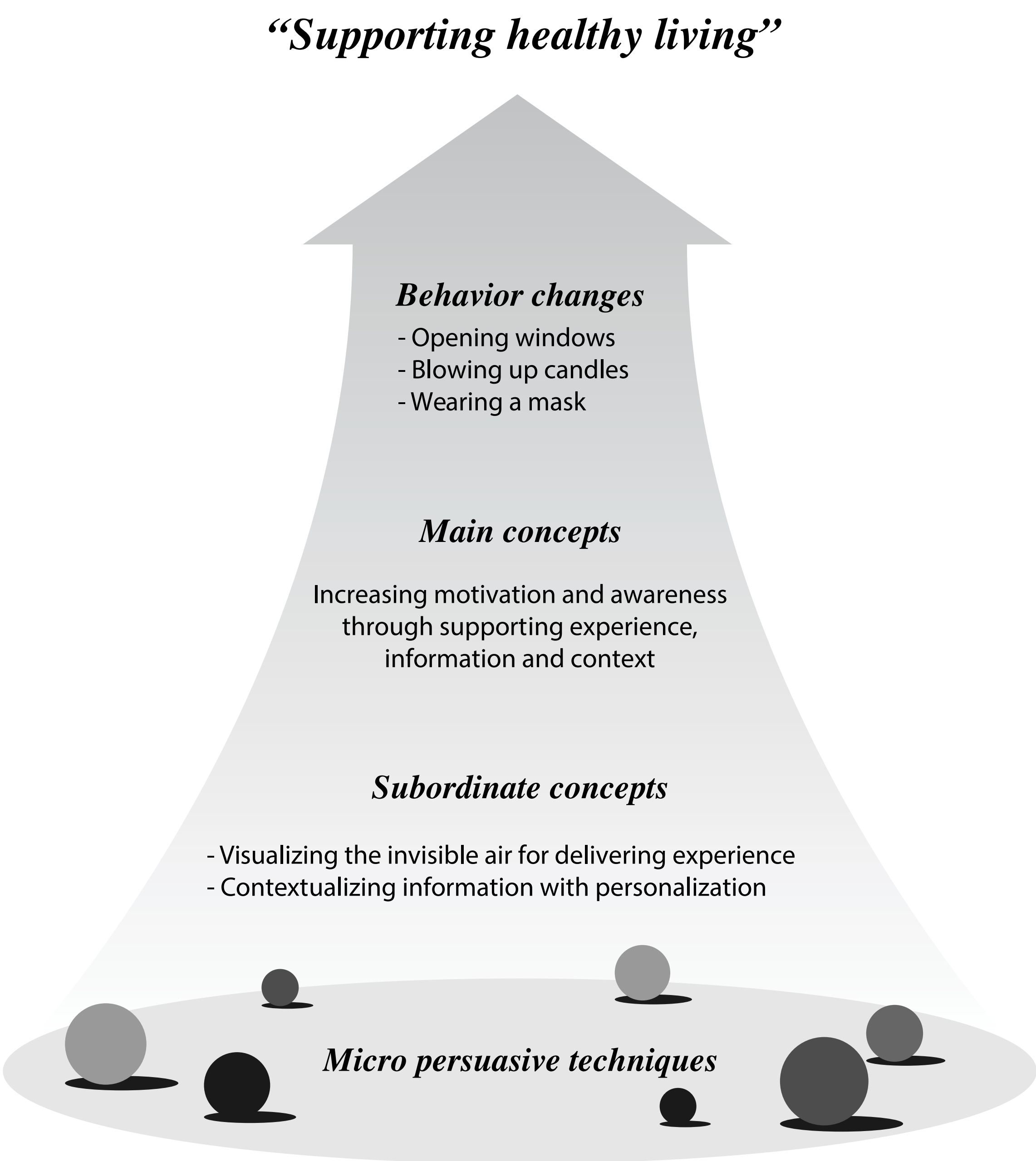


Figure 22: <The overview of case study>

4.1 PROJECT OVERVIEW

Based on the previous researches, an empirical case study applying insights to one of products in Philips – Philips Smart Air Purifier, had conducted. The big picture of the case study is increasing people's motivation for the 'Healthy Living' (See Figure 22), which is a part of the Health Continuum (Philips, 2015) – a framework defining business areas of Philips in healthcare (See Figure 23). To achieve the big picture, the study brought a main design concept – 'increasing motivation and awareness of people in User Group 2 (See 4.4.2 Target User Group) through supporting their experience, information and context'. To actualize those macro ideas: the big picture and the main design concept, the study brought detailed subordinate concepts (See 5.1.2 Subordinate Concepts) with micro techniques for persuasive interventions (Fogg, 2003, pp. 17-22).

4.2 METHODS AND SCOPE

The case study conducted three times of iteration creating quick and dirty prototypes, getting feedbacks from users and applying it repeatedly (Nielsen, 1993). The main reason that the project had the iterative process came from the difficulty of understanding people's psychological and cognitive interpretations about diverse visual languages based on their contextual differences. Even though project had many theoretical supports that could help to understand the varieties of the human behavior, but it had still many ambiguous parts that should be empirically observed and investigated more.

The case study did not involve designing a new air purifier, since it has a specific scope for visual communication design, so the digital products, i.e., mobile application and Internet-connected device, were considered as the most effective media under the scope.

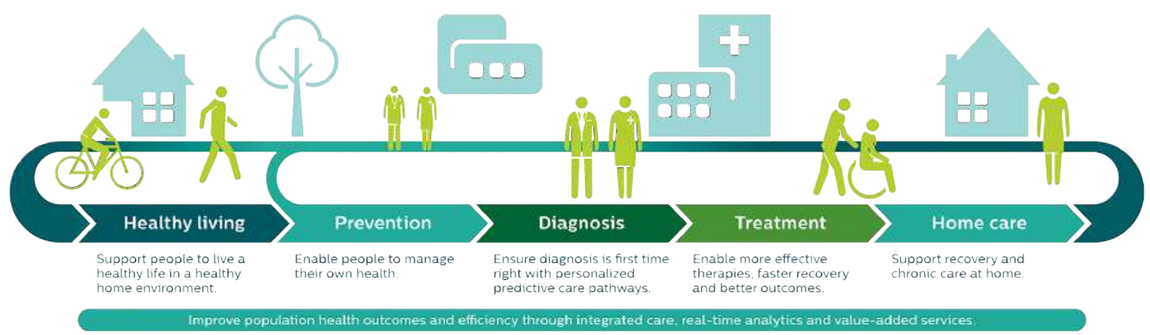


Figure 23: <Philips health continuum (Philips, 2016)>

4.3 RESEARCH FOR PHILIPS SMART AIR PURIFIER

Before starting the case study, basic desk researches for the products were necessary. The study investigated the context of Philips Smart Air Purifier and its mobile application, used the products in a real life context, and had an interview with a Philips designer who participated in the development of the Philips Smart Air Purifier mobile application.

4.3.1 PHILIPS SMART AIR PURIFIER

In Internationale Funkausstellung (IFA) 2013, Philips announced that the new Philips Smart Air Purifier will be in the market and they successfully launched it in China in early 2014 (Philips, 2013). Since China has serious air pollution issues wherein that 1.6 million people die every year, or 4,400 per day, the need of having clean air was urgent (Rhodan, 2015). Since the time, the company has tried to help improving the users' health and well-being by providing useful insights from air quality data.

The current designs of Philips Smart Air Purifier consist of two products: a mobile application and the air purifier (See Figure 24). These products work together through a cloud server synchronizing air data from a Wi-Fi connected air purifier to one's mobile application.

Figure 24: < Philips Smart Air Purifier(left) and Philips the Smart Air (right) (Philips, 2014)>

4.3.1.1 AIR PURIFIER

Philips Smart Air Purifier has an air sensor (4) which can detect indoor air quality in real time (See Figure 25). Throughout measuring the real time air data, the air purifier shows the current status of the air quality through an LED light (3). In detail, when indoor air quality is good, the product illuminates with a blue color, and when it comes to unhealthy air quality, it indicates a red color. The visual communication through LED light triggers users to recognize the indoor air quality.

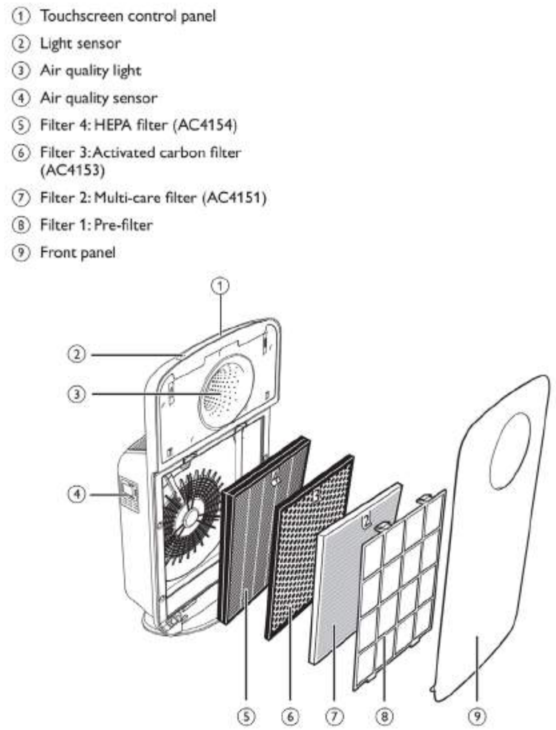


Figure 25: <Philips Smart Air Purifier user manual (Philips, 2014)>

4.3.1.2 MOBILE APPLICATION

The mobile application also uses the same colors with the air purifier to represent different air qualities. The main UI is divided into two sections: indoor and outdoor air, which helps users to understand the both information at a

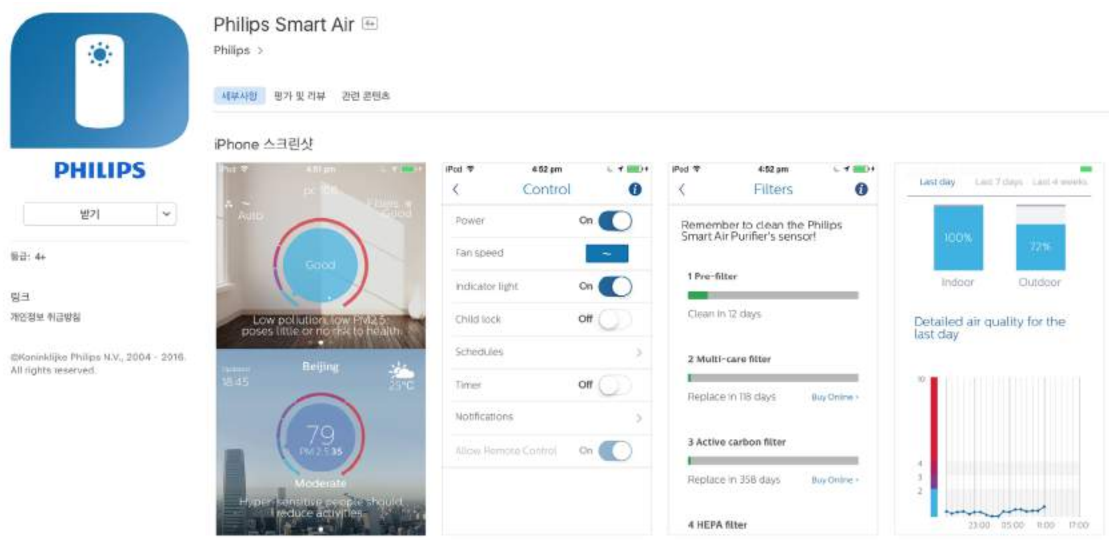


Figure 26 <Philips Smart – mobile application (Philips, 2015)>

glance (See Figure 26). By doing so, users can compare indoor and outdoor quality at the same time for making behavioral decisions, e.g., one could decide staying in her/his house instead of doing outdoor activities when the outdoor air quality is unhealthy. With the background images of the main page, the application uses evocative photographs representing an air quality of the place, e.g., when air quality is good in one's house, it shows clean and bright room as a background.

Historical air data visualizes the amount of clean air that one might have breathed during a day, a week and a month. Based on the histories of clean air consumption, people can be aware the air surrounding them. Air map illustrating the current outdoor air qualities in different geographical locations supports users to compare regional air qualities.

In a perspective of the behavior change, the current Philips Smart Air Purifier application has features supporting the decision makings of users. In particular, it conveys suggestions such as encouraging outdoor activities, opening windows, wearing a mask and so on. The filter alerts also allow people to know right timing of cleaning or purchasing new filters.

—

4.3.2 USING PHILIPS SMART AIR PURIFIER IN A REAL LIFE CONTEXT

To understand the current Philips Smart Air more deeply, the products: air purifier and mobile application, had been used during four months in a real life context; it was installed in a room, and used for the purpose of analysis (See Figure 27). Experiences through using the product provided not only deeper understanding of the product, but also more empathic interpretations of users.

Due to the confidentiality issues between this thesis and Philips, the analysis results of the product cannot be specifically illustrated on this paper, but findings and insights were properly applied in following design iterations.

—

4.3.3 AN INTERVIEW WITH A PHILIPS DESIGNER

For further understanding of Philips Smart Air Purifier and the context of China market, an interview had been conducted with one of Philips designers who participated in the development of the Philips Smart

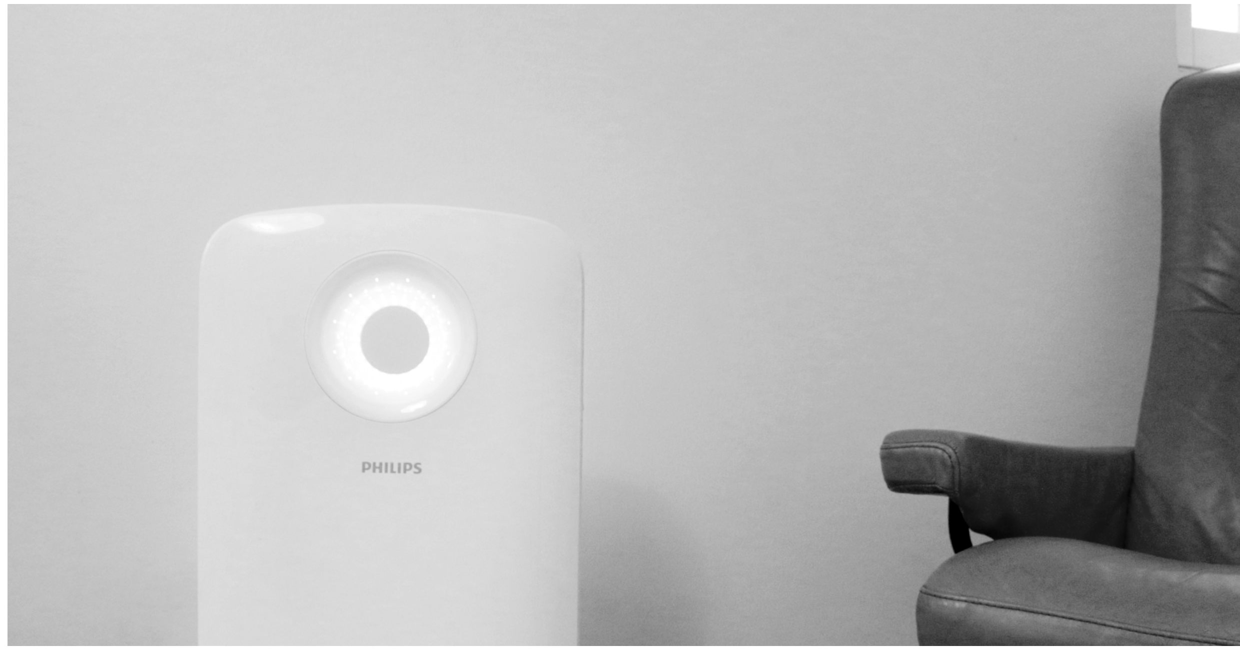


Figure 27: <Using Philips Smart Air Purifier>

Air Purifier mobile application.

The designer explained the holistic approaches of Philips in the air business, the situation of their products in the global market and the future vision of Philips in the business area. It gave an opportunity to understand the aims of the company: satisfying users' needs by providing clean air and supporting users' decision makings through data.

Due to the confidentiality issue, the contents of the interview cannot be specifically shared on this thesis.

4.4 ITERATIVE DESIGN

The final design had been developed three times through iterative process creating quick and dirty prototypes, getting feedbacks from users and applying it on the design repeatedly (Nielsen, 1993). The main reason that the project had the iterative process was the difficulties of understanding people's psychological and cognitive interpretations about diverse visual languages. Even though project had many theoretical supports that could help to understand the varieties of the human behavior, but it remained many ambiguous parts that should be empirically observed and investigated more. For this reason, the case study had two rounds of evaluation processes and third time of designing processes to produce the final design outcomes.

4.4.1 INITIAL PROBLEM DEFINITION

The application of Philips Smart Air Purifier is well deliberated for helping users have clean air in their home and outside. It is visually easy to understand, clearly shows the status of indoor and outdoor air quality, and gives useful insights that users could consider for decision makings.

However, in terms of the changing behaviors, it could have more actionable insight that people can follow. It does not specifically remind or guide users for a behavior under a situation, e.g., when a home air quality is dramatically decreased, one would not know the reason of it and the ways of improving air quality except using their air purifier. In addition, it does not reflect the diversity of users' motivations, which is crucial in behavior change. It delivers generalized insights for all users who have different motivation levels and contexts. It also does not give sufficient motivation to keep using the mobile application. The air purifier detects air quality and automatically works alone, so people do not necessarily open the application and see different data collections.

The initially defined problems were used for the first design iteration, and it was redefined through the first evaluation (See 4.4.6 Concept refinement).

4.4.2 TARGET USER GROUP

As the research hypothesis has been proved, people who have different motivation levels regarding air quality should have different interventions (See 3.4.4 The Synthesis of Research Findings and Insights). To build concrete design outcomes, the project needed to focus on a specific user group that would have the most potentials in behavior change. Among 4 different user groups, User Group 2 was considered as the most effective and potential group for making impactful results through design outcomes (See 3.3 Research Method and Scope).

The first design iteration was focused on the users of Philips Smart Air Purifier in User Group 2 who have been using the product. However, from the second iteration, the project enlarged the scope of the target group to non-users in User Group 2. Since the project realized that having an air purifier is already an obstacle for general people who cannot financially afford it, the target group had decided for all people who share similar motivation levels regarding having clean air regardless of whether they have the product or not.

4.4.3 USER PERSONAS

In order to successfully build products reflecting users' needs and desires, personas: fictitious characters based on real life users, were created to have a deeper understanding of users and utilizing it as a key component of driving design processes while wearing their glasses (O'Connor, 2011). By doing so, iterative processes were expected to bring empathic approaches for making valid final design outcomes.

Figure 28 illustrates the position of each persona through motivation levels and vulnerabilities from their contextual differences. In order to focus on the target user group, Veera: the representative persona of User Group 2, had been elaborated more (See Figure 29).

Veera lays on the middle of motivation (X) and relatively low of vulnerability from contexts (Y). She represents User Group 2 that has the most number of common users of Philips Smart Air Purifier or non-users. Based on her current status, the new concept designs were purposed on increasing her awareness and motivation through interventions, so that she could ultimately move toward the right side of X where User Group 3 is located. The changed behaviors of Veera will be illustrated in the Chapter 5. Final design outcomes (See 5.1.4 Behavior changes).

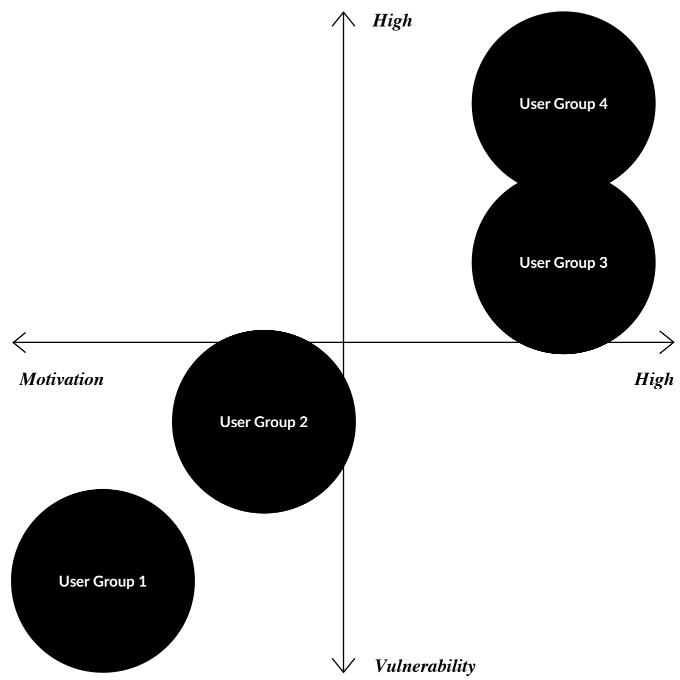


Figure 28: <User personas>

BACKGROUNDS OF VEERA

Veera (23) is a Finnish girl who is studying in a university in Shanghai at the moment (See Figure 29). She lived in Helsinki before going to her bachelor study, but decided to study the business in China by her interests. For these reasons, she moved in to Shanghai 2 years ago. She is currently working at a part time job in a café 3 days a week. Except for the working hours, she usually studies her major and Chinese in the school library. She is an extrovert and an outgoing person, so usually she spends her weekends for social life: meeting her friends or visiting interesting places with them in Shanghai. She has a cat in her house, and regularly cleans the house once a week.

Before coming to Shanghai, she had not seriously considered the air quality issues in her life. Even though she usually has a light pollen allergic symptoms during the spring and autumn time, she did not consider it as a critical issue. Since she believed that air is always quite clean in Helsinki, she had thought that clean air is an ordinary element that anyone can easily get. However, from the time moving to Shanghai, she started to consider air quality issues in her daily life, because there is often unhealthy air in the city, and she has seen that some friends were wearing masks when the air quality was critical. She has heard that the air quality could affect her health condition, but does not know the details. She knows that she might need to use a mask, but for her, it is hard to remember or carry a mask every day.

"Well, surely I know that I should care about the air pollution, but it's hard to carry a mask all the time. I am not even sure whether this mask protects me or not. Also, even in days moderate air quality is common, I can see many people are just walking around the city, so sometimes I am confused."

When she just moved to Shanghai, she occasionally checked the air quality forecasting on the Internet, but nowadays she lost her motivation checking air forecasting every day. Instead of that, when

Figure 29: <User persona: Veera>

the outdoor weather is sunny, she regards that the air is clean.

"I cannot see the polluted air, so I usually think that if the weather is sunny or raining, the air is clean."

4.4.4 THE FIRST ITERATION

In order to resolve the initially defined problems, rough ideas had been collected from the very beginning of the project. Especially, the results of the user research: Online surveys, user interviews and Co-Design workshops, gave many practical ideas that could be examined in the iterative design process.

As a result of the researches crystallized, the cornerstones of behavior changes in this project are 'the increase of the users' motivation and awareness through enhancing experience, information and context of users. To accomplish this main idea, initial design concepts were categorized into 3 sections: visualizing the invisible air, contextualizing information with personalization, and delivering experience.

These first design concepts had been utilized until the final design outcomes, so the details of each design concepts will be explained in the Final design outcomes (See 5.1.2 Subordinate Concepts).

4.4.4.1 CONCEPT DESIGN #1: WORKING PROTOTYPE AND WORKFLOW DIAGRAM

The first conceptual UI design of new Philips Smart Air Purifier application followed the basic visual identities of the current UI design, i.e., colors, divided sections for indoor and outdoor air quality on the main page and typography. Based on this foundation, the first design iteration followed the initial design concepts: visualizing the invisibility of the air, contextualizing information with personalization and delivering experience. The final results of the first design iteration include a working prototype via InVison (invisionapp.com) and a workflow diagram: a visual representation of the holistic flow of a product (See Appendix4: < The 1st iteration: workflow diagram >).

To examine interventions and to make a clearer information structure, main menus were divided into four sections: Current Air, Dashboard, Insights and Filters. Along with it, a Control panel allowing users to remotely control their air purifiers and Settings menu for adjusting options were added (See Appendix 5: <The 1st iteration: UI design>).

4.4.5 EVALUATION #1

The evaluation of the first iteration was conducted with 8 Philips employees in the Netherlands during 3 days in June, 2016. In order to get insightful feedbacks and constructive critics regarding the findings of the researches and the initial design outcomes, professionals who are related to the thesis topic: people researchers, data designers, a data scientist, UX designers, Art directors, separately participated in the evaluation.

4.4.5.1 METHODS

Method for the evaluation included a presentation, questionnaires, a digital prototype and a printed workflow diagram. The presentation explained previous desk research findings and the ways of transforming the knowledge into the initial design outcomes. In order to test the outcomes, a digital prototyping and a printed workflow diagram were prepared. The questionnaires aimed to get diverse opinions from the participants who have various background knowledge regarding the subject, and it allowed to achieve fruitful feedbacks that the study had insufficiently considered.

4.4.5.2 KEY FINDINGS AND INSIGHTS

Philips employees gave many productive feedbacks through the 1st evaluation. In general, they showed positive feedbacks regarding the idea of visualizing invisibility of air and appreciated the findings and insights from the previous researches. However, the study tried to get constructive feedbacks as many as possible through the opportunity, so it asked to them to give more critical opinions.

UNCLEAR TARGET BEHAVIORS

The first comment that had been constantly issued during the evaluations was the unclearness of target behaviors. Even though the initial outcomes had design features that could possibly influence the users' behaviors while increasing their awareness and motivation, the anticipated results were unclear due to the lack of clarity in the target behaviors. For this reason, the project needed to have clear lists of target behaviors, so that interventions could focus on the specific behaviors through visual communications.

ENLARGING POSSIBILITIES THROUGH DATA UTILIZATION

Through discussions with data designers in Philips, the project found more opportunities in data utilization that would possibly increase the awareness and motivation of users. The data utilization in the first concept design was somewhat limited in conventional ideas, but the possibility can be enlarged through diverse combinations of existing quantitative data sets and collections of new data from environments. For example, by tracking the users' daily commutes via Global Positioning System(GPS) and combining it with outdoor air data, the system could suggest a new commute that has a cleaner air quality.

INVOLVING USERS

The ways for making constant involvement of users had been discussed throughout the evaluation. Unlike other social network services that have almost unlimited new information with constant triggers and rewards for making users unknowingly put in the Hooked cycle (See Figure 6), an air purifier application is 'a purpose-driven digital service', which means that users could mainly utilize the application to satisfy their specific purposes such as checking air quality and controlling an air purifier. Under such differences in terms of the purpose of using application, a question – 'how to make people constantly use this application in their everyday lives', had been discussed. To achieve possible answers for the question, previously studied frameworks in the desk researches: The hooked model, the behavior model and motivation theories, had been reviewed again. The developed design examples of making users' constant involvements will be illustrated in the chapter 5. Final Design Outcomes.

HEALTH

Since the big picture of this project is supporting the users' healthy living (See 4.1 Project Overview), health aspects in the application should be developed more. Not only providing general health information regarding air quality, but also providing long-term effects of diverse air qualities for different target users were necessary. In detail, information that could increase the users' awareness and motivation as a preventive aspect was discussed in the evaluation, e.g., visualizing the anticipated changes of the health condition of a baby under unhealthy air qualities in different time spans.

STORYTELLING

There were opinions that the initial outcomes do not efficiently convey a story that combines diverse design elements. The visual designs needed to have one key design language is to make the outcomes more attractive and interesting, but due to the lack of connectivity between different design elements, the provided information seemed to be disconnected from each other.

To handle this issue, the 2nd design iteration considered creating a key design language that could bridge different visual elements. Emoticons and colors were considered as the most effective ways of communicating data in this context, so other elements: photographs, numbers, texts would be minimized through the next design iteration (See 5.1.3.1 Emoticons).

THE NEGATIVE EFFECTS OF DUST VISUALIZATION

One of the key design elements in the first design iteration was visualizing the invisible air (See 4.4.4 The First Iteration). As part of it, the project used dust visualization in the Filters illustrating the collected dust on filters. The intended effects of this visualization was delivering an urgency of cleaning or changing filters and was conveying the feeling of satisfaction that an air puffier has effectively cleaned the dust, which was floating in the air before (See Appendix 5 <The 1st iteration: UI design: Filters>). However, this intention was not evaluated by users until that time, so the anticipated results of it was uncertain.

Evaluators were concerned about the possible negative influences of the visualization, e.g., it can be understood that the air purifier does not work well, or it can bring negative images of the brand. For these reasons, the visualizing dust on Filters will be examined at the 2nd evaluation (See 4.4.8.2 Key Findings and Insights).

DATA FROM USERS, BEHAVIORS AND ENVIRONMENTS

The previous design outcomes had a lack of consideration in different data sources: users, behaviors and environments, so the project needed to reconsider diverse data sources that could bring different possibilities: users, behaviors and environments

USERS

First of all, the data of users that comes from their personal context already have various details telling the needs and desires of them. This data has already existed before using a product, so interventions should collect the data when people start using the product or while using the product.

BEHAVIORS

Data from the users' behaviors while using a product is an also important resource. The system can collect data from the users' behaviors, analyze it and convert it to doable suggestions that could positively enhance their behaviors and attitudes. By doing so, users can track the collected data and the analyses, so that they could see the relation between accumulated the results of their behaviors and the anticipated health effects from it.

ENVIRONMENTS

Environments surrounding users generate influential data as like other data sources. Since the diversity of data from different environments are varied and changing rapidly, there was a need for collecting accurate real-time air data from the users' geographical location. This need was developed through a concept refinement process (See 4.4.6 Concept Refinement), and helped to create a new design idea – Smart Air Detector (See 5.1.3.1 Smart Air Detector).

4.4.6 CONCEPT REFINEMENT

The holistic concept of the project had been redefined after the first evaluation. The concept refinement tackled two main issues that had founded: creating clear target behaviors that interventions try to achieve and redefining core problems of users.

4.4.6.1 SELECTED TARGET BEHAVIORS

The lists of target behaviors were more specified from previously defined behavior suggestions (See 3.4.3.2 Behavior Suggestions). Due to the complexities and difficulties of challenging behavior changes, the project selected the most achievable and desirable target behaviors that could be examined in the 2nd iteration. The selected behavior challenges were:

- *Open windows*
- *Blow out candles*
- *Wear a mask*

4.4.6.2 REDEFINING PROBLEMS

Redefining problems started with a critical question; 'what do people really want to know about air quality?' There is an enormous amount of data and information that people can access and understand, but the core need that people are truly eager to know was not sufficiently reflected in the first design outcomes.

Research results had been rechecked and reconsidered to figure out the key problem of this project. In the end, only one core idea remained; '*people want to know the air quality in which they are standing*'. Users want to know air quality wherever they are: at their home, in their office, in their city and in their country. As one of the findings from the desk research showed, the most desirable information about air quality were the status of indoor or outdoor air quality and the ways of improving air quality or avoiding it (See 3.4.1.2 The Changes of Motivation and Desirable Information). However, the derived problems from this core need had not been solved via first design solutions. In more detail, people should buy air purifiers to know their home's air quality and purify it. However, even if they have the air purifier, it does not let people know about the air qualities in specific locations, e.g., office, public transportation, road, store and so on, or the ways of improving the air quality in those locations. In other words, when users purchase an air purifier, they can only have clean air in their home. Even though people can access to API data for outdoor air quality, but it is often too generalized information in a vast area.

4.4.6.3 DEVELOPED DESIGN CONCEPT

To resolve the redefined problem, the project should have a new idea that could collect real-time data from any location in which users are standing and find effective ways of communicating visuals through the data. Due to this reason, the study created an 'air measuring device' that can collect air data regardless of its location. Through the device, people could know the correct air qualities wherever they are: in a house, in an office, at a friend's home or even in the middle of a forest. The device also communicates the current air quality data through emoticons and colors on the screen of the device, so that people can immediately recognize the air quality in any place. In addition, the users could get behavior suggestions through the mobile application, so they can know what they are able to do in the situation.

4.4.7 THE SECOND ITERATION

4.4.7.1 CONCEPT DESIGN #2: PROTOTYPES

The second concept design combines two ideas: an air measuring device and a mobile application. Since the emergence of the new idea and the necessity of reflecting feedbacks from the results of the

Figure 30 <Quick prototype>

first evaluation, the entire UI design of the mobile application should be reconsidered. The previous UI design followed the general visual identity of the current Philips Smart Air Purifier application (See 4.4.4.1 Concept design #1: Working Prototype and Workflow Diagram), but the second concept design did not use it anymore, because it should have a key visual language conveying a visual story for both of the data measuring device and the mobile.

The data measuring device was initially actualized with concept images and a quick prototype with affordable materials (See figure 30). The quick prototyping shaped the rough idea to a more tangible object and highlighted further possibilities beyond the surface of the idea (Brown and Katz, 2009). The quick prototype had been used for getting feedbacks in the 2nd evaluation.

The digital prototype of the mobile application was recreated. It started from sketches on papers to vector files through a graphic design program and got interactive functions through InVision (invisionapp.com).

The details about the design features will be illustrated in the Final design outcome (See 5. Final Design Outcomes), since the results of the second iteration is close to the final outcomes.

4.4.8 EVALUATION #2

The second evaluation was implemented with 4 participants who were categorized in User Group 2 (See 3.3 Research Method and Scope). 3 participants already joined the previous user researches: Online survey and Co-Design workshop, so they already had an basic understanding of air quality in terms of the behavior change that the project tries to challenge.

The focus of the evaluation was to examine the success of target behaviors (See 4.4.6.1 Selected Target Behaviors) through the design outcomes. Rather than getting general feedbacks regarding design outcomes, the evaluation was specifically asking defined behavioral elements: awareness, motivation, simplicity, trigger and general user experience, to confirm whether target behaviors were successfully achieved or not (See Appendix 6 <Evaluation paper>).

—

4.4.8.1 METHODS

To achieve successful results in the second evaluation, the project prepared materials that would make people have a more empathic mindset and a feeling of reality regarding contexts of using the design outcomes (See Figure 32). Firstly, the hypothetical user's contexts were explained via a presentation with relevant images. The contexts came from a selected persona's daily life (See 4.4.3 User Personas); in Shanghai, these are working in her/his office, having dinner at a friend's home and traveling from her/his home to the office in the morning (See Table 4). Based on those contexts, the evaluation intended to induce users' behavior changes individually: opening windows, blowing out candles and wearing a mask. While explaining the contexts and testing prototypes, physical probes; windows, candles and masks, that were expected to bring a feeling of reality, were provided to evaluators (See Figure 31).

After understanding the contexts, participants got prototypes. Firstly, they got a prototype of the measurement device showing certain emoticons with colors communicating the current air quality in the context. After that, they could check a working prototype of the mobile application providing interventions related to each context (See Figure 31). While using the prototypes, participants were asked to directly describe their feelings and thoughts, and it had been observed by a coordinator – an explicit method for evaluation (Strasser et al., 2012).

After using the prototypes, evaluation papers were given to the participants. The criteria of questions were segmented into the general success of behavior change, increased motivation, increased awareness, simplicity of the behavior, increased simplicity and trigger on right timing. Participants answered each question via a grading system from 1 to 10 (1: strongly disagree and 10: strongly agree) and were interviewed for the clarification of reasons they made. (See Appendix 6 <Evaluation paper>).

—

4.4.8.2 KEY FINDINGS AND INSIGHTS

User context		
You're working in Shanghai, generally knows about the air quality issue in the place. However, you're not hyper sensitive about air quality surrounding you, so you haven't considered it as a major issue in your daily life. You purchased Philips Smart Air Detector recently, and now just started to use it. You don't have an air purifier in your home.		
Context 1: Open windows	**Context 2: Blow out candles**	**Context 3: Wear a mask**
You are in your office in Shanghai in the middle of afternoon. Windows in the office are closed, and barely ventilated. The office does not have an air purifier. An air detector notifies that air is moderate.	You are invited to your friend's home. Your friend has an air purifier. To make a gentle mood, your friend uses candles. After 10 minutes, you could not feel, but the air detector and the friend's air purifier indicate air quality in the space is unhealthy.	You wake up in the morning at 7:00 a.m., and got an alert that the air quality in Shanghai would be very unhealthy for today from your mobile. You should go to the office to work until 9:00 a.m.
Design probes used in evaluation		
Window	Candle	Mask

Table 4: <Contexts and probes>

The results of the second evaluation were analyzed through coding methods (Saldana, 2009). The overall success of behavior change was positive, most of the participants answered that delivered design interventions are highly likely to change their behaviors in the given contexts (average: 9/10) (See Figure 33 to 35).

FINDINGS

First, a result of first behavior challenge: opening windows, showed that participants would change their behaviors through delivered information and interventions (average: 8.75/10). Simplicity recorded the lowest average (7.25/10) in the first behavior challenge. Increased motivation through interventions indicated 7.5 out of 10, which was the second lowest score among all questions. (See Figure 33)

Secondly, blowing out candles resulted in 8.75 out of 10; participants agreed to the fact that interventions would change their behaviors. Triggers on the right timing and increased awareness showed the highest averages 9.25/10 and 9/10 respectively. Increased motivation showed 8.25, which was relatively lower than other criteria. (See Figure 34)

The third behavior challenge: wearing a mask, showed the highest average score (9.5/10) among all challenges. Increased awareness resulted 9.25/10 as the second highest average, and increased motivation followed third with 9/10. Increased simplicity and trigger showed a relatively lower score with 8.25/10 in comparison to other criteria. (See Figure 35)

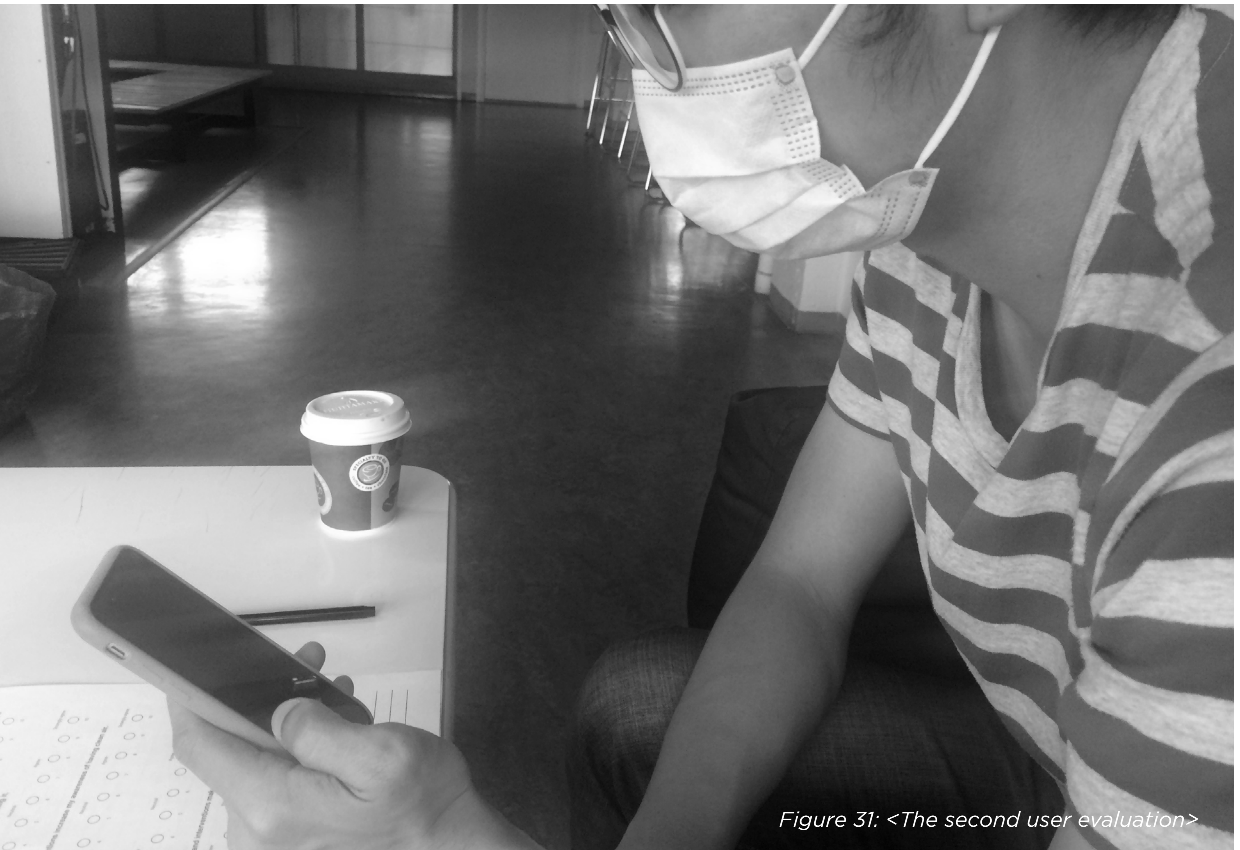


Figure 31: <The second user evaluation>

Figure 32: <Evaluation materials>

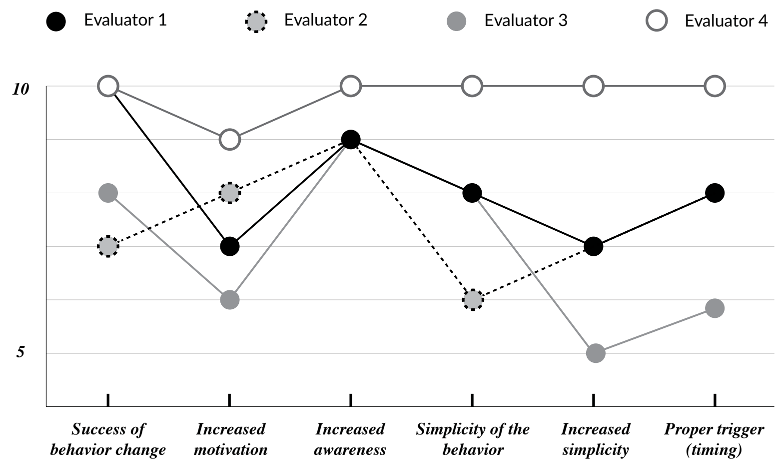


Figure 33: <The result of fist behavior challenge: opening windows>

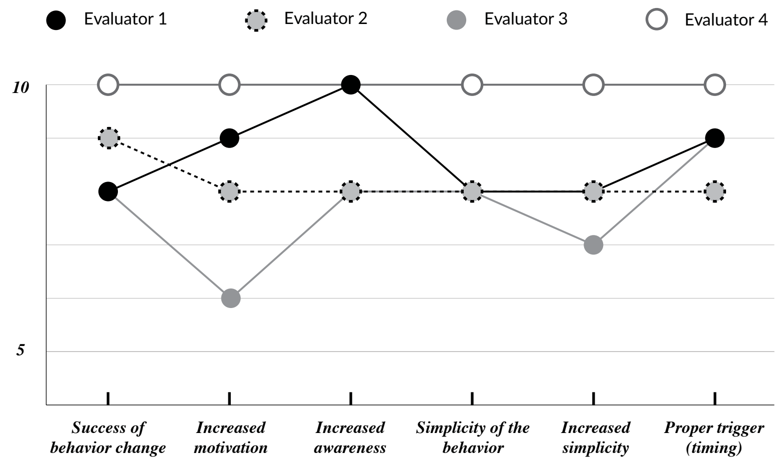


Figure 34: <The result of second behavior challenge: blowing out candles>

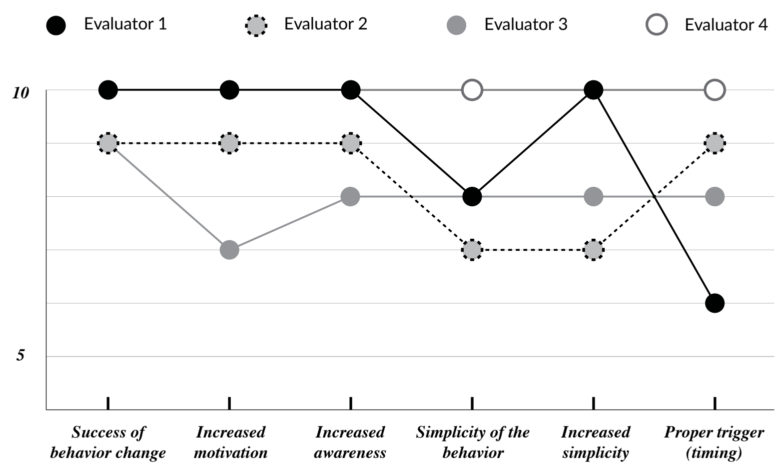


Figure 35: <The result of third behavior challenge: wearing a mask>

INSIGHTS

In each behavior challenge, increased motivation scored relatively lower grades than others, especially in comparison with increased awareness. Participants explained the reason that the motivation is gradually increased than the awareness. In other words, the awareness could be instantly increased through information and interventions, but the motivation is slower, since accumulated awareness makes increased motivation (Prochaska et al., 2008, p.101). In a nutshell, the increasing motivation can be regarded as a long-term goal, and the awareness is relatively easily increased by effective interventions and information.

Even though the evaluation gave specific contexts for each behavior challenge, most of the participants mentioned that there were still many micro elements depending on the contexts that could ultimately influence their behaviors. For example, when they focus on their work or during a meeting in the workplace, they would accept the notification as a distraction even though they realize the air quality in the place is unhealthy. However, when they have time to accept the notification as an important information, the intended behavior change: opening windows, would more likely to happen. Briefly, the various contexts of users at a specific moment would make differences in behavior change.

Another repetitive comment from most of the participants were that the provided information was too detailed. Considering that the target group was User group 2 (See 3.3 Research Method and Scope), delivered information was higher than desired. Participants did not usually read long texts or check the details of the graphs. They instantly understood the given information with colors, emoticons and symbols, and then decided whether to do the recommended behavior or not.

Dust visualization in the Filter page were specifically asked to all participants due to the possibility of accepting it in negative ways (See 4.4.5.2 Key Findings and Insights). There was an opinion that the visualization could be accepted as a strong warning message, but they did not accept it as the meaning of poor quality or negative brand image of Philips as the study was concerned.

4.4.8.3 FINAL REFLECTION

Based on the second evaluation, the final reflection was conducted as a third iteration. Since the result of the evaluation was reasonably positive, the project did not change core ideas in the design outcomes. Most design elements were maintained, but too detailed information was simplified, and small improvements in Onboarding process were added. The outcomes of final reflection will be described in the following chapter 5. Final Design Outcomes in detail.

5. FINAL DESIGN OUTCOMES

'CLOSED WINDOW'
UNHEALTHY
PM 2.5 238

'OPENED WINDOW'
VERY CLEAN
PM 2.5 23

Figure 36: <Smart Air Detector in a context>

5.1 FINAL DESIGN CONCEPT

After implementing the last reflection through the 2nd iteration process, the final design outcome had been derived. The final design concept that had been developed through iterative design processes is 'increasing the users' motivation and awareness through experience, information and context'. To support this main concept, two subordinate concepts: visualizing the invisible air and tailoring information (with layered information) and providing personalization, were constructed.

5.1.1 MAIN CONCEPT: INCREASING AWARENESS AND MOTIVATION

As the results of the researches and the iterative designs identified before, developing awareness is closely related to increasing one's motivation (See 3.4.4 The Synthesis of Research Findings and Insights). In other words, by being aware about a subject, one could start to consider the subject and ultimately initiate increasing motivation to have desirable results (Brewer and Rimer, 2008, p. 155).

The increased awareness and motivation could be actualized throughout the consideration of experience, information and context, which had defined through the analysis of the user research (See 3.4.4 The Synthesis of Research Findings and Insights). Namely, by stimulating users' emotional aspects, rational thinking and reflecting contextual differences could contribute to the development of awareness and motivation. To successfully achieve those elements through the final design outcomes of the target group (User Group 2) (See 4.4.2 Target User Group), the project built subordinate concepts based on research findings and insights.

5.1.2 SUBORDINATE CONCEPTS

VISUALIZING THE INVISIBLE AIR FOR DELIVERING EXPERIENCE

Through visualizing the invisible air, users could get an immediate understanding of the air quality surrounding them and experience it through virtual simulations. This method satisfies delivering 'experience' through visualized air quality to increase users' awareness and motivation.

The project visualized different air qualities mainly through emoticons, colors and dust animations, which are composed of sensory symbols (See 2.1.1 Information; 2.2.2.2 Sensory Versus Arbitrary Symbols) that stimulates the automatic system of the human brain (See 2.1.1 Human). Those visualizations are effective to trigger the emotional aspects of users and rapidly communicate information, so that people can immediately and unconsciously understand it without rational considerations to digest the provided information.

CONTEXTUALIZING INFORMATION WITH PERSONALIZATION

As the research hypothesis had proved (See 3.4.4 The Synthesis of Research Findings and Insights), the ways of nudging people should be differentiated based on their different motivation levels. To accomplish it, the project categorized the content and quantity of information in products for diverse user groups that have contextual differences and different motivation levels regarding air quality. This method satisfies 'information and context' by layering information and providing personalization for developing users' awareness and motivation (See 3.4.2.2 Awareness and Motivation; 3.4.4 The Synthesis of Research Findings and Insights).

To efficiently achieve this concept, the information (See Figure 21) was structured and correlated with the users' motivation levels, which have the same criteria with divided user groups. Table 5 illustrates a correlation of information layers and different user groups. In detail, for people who have low motivation regarding having clean air (User Group 1 and 2), simple and general air information could be mainly delivered, e.g., current indoor and outdoor air quality. On the contrary, for users who have high motivation and significant contextual differences (User Group 3 and 4), they would get a more tailored and detailed information reflecting their situations (See 3.4.4 The Synthesis of Research Findings and Insights).

Default options	Information layers	User Groups	Functions					
			Dashboard	*Insights*	*Health*	*Filters*	*Profile*	*Alerts*
Simple	Simple	User Group 1	• Notification bar • Current air • Data visualization: Air surrounding you and Pollutants	• Simple suggestions	• General health information	• Filter status • Video materials; how to clean filters and how to manage the air purifier	• Personal information updates • Managing devices	• Non active
Normal	Moderate	User Group 2	• Notification bar • Current air • Data visualization: Air surrounding you, Air map and pollutants	• Suggestions reflecting one's context	• Health information reflecting one's context	• Filter status • Video materials; how to clean filters and how to manage the air purifier	• Personal information updates • Managing devices	• Active only for unhealthy air quality
Expert	Detailed	User Group 3 and 4	• Notification bar • Current air • Data visualization: Air surrounding you, Air map, Air history and pollutants • Air report • Allergy forecasting	• Detailed suggestions reflecting one's context and health issues	• Detailed health information reflecting one's context and family members' vulnerability	• Filter status • Video materials; how to clean filters and how to manage the air purifier	• Personal information updates • Managing devices	• Active for positive and negative air quality

Table 5: <Information layers for diverse user groups>

5.1.3 CONCEPT PRODUCTS

The final concept products consist of an air detector and a mobile application. With the Philips Smart Air Purifier, the concept products simultaneously work together to deliver real-time air data with doable insights (See Figure 37).

The air quality data can be measured and collected by the Philips Smart Air Purifier, Smart Air detector (See 5.1.3.1 Smart Air Detector) and the public API. The air detector can collect accurate air data anywhere people visit, which is a pillar supporting the limitation of collecting air data through Philips Smart Air Purifier and API data (See 4.4.6.2 Redefining Problems).

The collected data sets are visualized in the Smart Air Detector as well as in the mobile application, so that people can monitor things happening around them. Compared to the earlier product, the new concept products aim to deliver a more tailored information with doable insights for motivating users constantly.

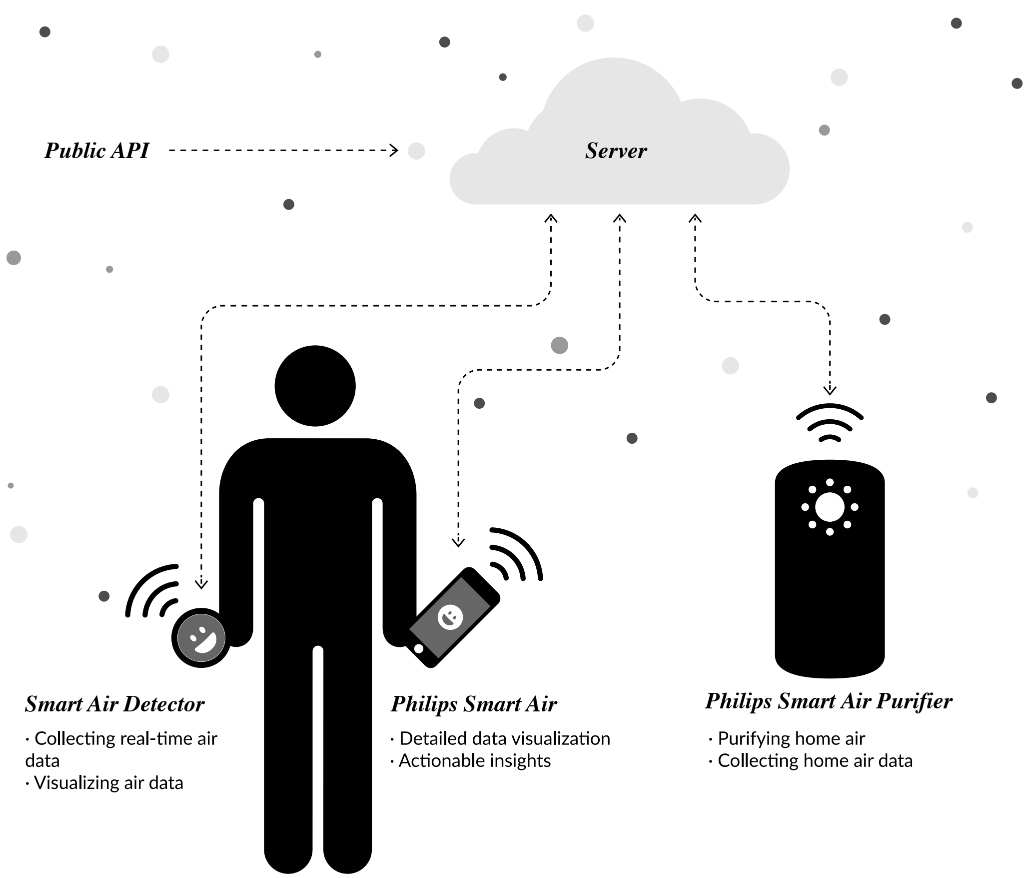


Figure 37: <The system of products>

5.1.3.1 SMART AIR DETECTOR

The Smart Air Detector is a data measuring device that collects real-time air data in any location in which people are standing (See Figure 38). Users can freely carry it on their bag, clothe or their key ring and place it where they desire to (See Figure 39 and 40). The device automatically measures the current air quality data, and users are allowed to freely access to it. The analyzed air quality is represented by visualizations: animated emoticons, colors and descriptive texts, on its digital screen. By combining sensory and arbitrary symbols in the visualizations, it can convey information stimulating both of brain systems of users – Reflective and Automatic system, which helps users understand the given information more quickly and correctly (See 2.2.2.2 Sensory Versus Arbitrary Symbols). Of course, the data is also shared with users' mobile applications providing detailed information and suggestions that would guide users' following actions based on the contexts.

EMOTICON DESIGN

Emoticons were a key storytelling language that connects different data visualizations in both of concept products (See Figure 41). The visual representation of different emotional statuses (based on air quality) could communicate the virtual experience of an air quality (See 2.2.2.3 Emotion from Perception), which is hard to recognize through our senses (See 3.4.2.2 Invisibility of Air). In other words, users could alternatively experience the air quality through the emoticons that are regarded as living entities (Fogg, 2003, p. 89-90). It evokes different emotions of users based on air qualities, e.g., when one recognize that the current air quality in her/his place is unhealthy through emoticons (fear or apprehension), s/he might also feel the similar emotions with the emoticons (Wallbott, 1991; Dimberg et al., 2000). By evoking the users' emotions; people feel empathy through the emoticons, instead of rational understandings, the communication between users and products could be faster, more understandable and most importantly, more persuasive (Schultz et al., 2013).

The default emoticon designs are divided into 5 variations: joy, serenity, vigilance, apprehension and fear. The five emotions were selected based on the wheel of emotions, which shows the interplay of emotions and their varying levels of intensity (Plutchik, 1980). To put more emotional data in one graphic, emoticons are animated with dynamic movements just like a human facial expression.

Figure 38: <Smart Air Detector # 1>

Figure 39: <Smart Air Detector # 2>

Figure 40: <Smart Air Detector # 3>

VERY CLEAN
PM 2.5 23

Figure 41: <Emoticons depending on air qualities>

CLEAN
PM 2.5 82

MODERATE
PM 2.5 163

UNHEALTHY
PM 2.5 238

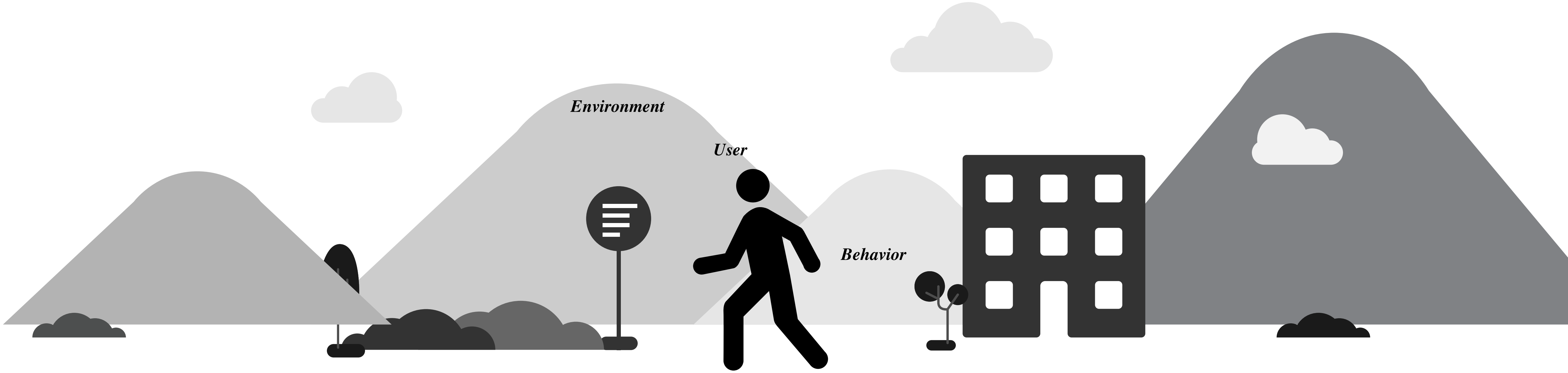


Figure 42: <Data sources: users, behaviors and environments>

COLLECTING DATA

Data can be collected from users, behaviors and environments through various media: Smart Air Detector, Philips Smart Air Purifier and public API data (See Figure 42). The collected data sets can be combined together and can make useful insights delivering doable behavior suggestions to users, i.e., outdoor air data can be combined with a GPS data of a user to suggest alternative commuting routes in which have cleaner air.

The Smart Air Detector collects environmental air data in any place regardless of its location. It automatically measures the real-time air quality in a place: P.M 2.5, P.M 10 and O3, and visualizes it on the screen. Through the data visualization, users can know real time air quality that is constantly changing, which can work as a variable reward making users habitually use the product (Eyal, 2014, pp. 95–133).

The mobile application can collect diverse data from users and their behaviors. To collect data from the users' contextual differences and the changes of the users' awareness and motivation levels, the application asks questions in different phases of using the application: Onboarding process, Notification bar and Profile (See 5.1.3.2 Philips Smart Air Purifier Mobile Application). The users' behavioral data is collected through the mobile application, i.e., one's patterns of using the application, the changes of one's geographical locations and the success of behavior change from interventions.

Air data collected from Philips Smart Air Purifier (home environment) and public API (outdoor air quality) can be also combined with other data sets, and provide a more tailored information and suggestions for users.

STORYTELLING FOR OTHERS

The Smart Air Detector can bring additional values by communicating stories to other people who have not considered the air quality as an important issue (User Group 1 and 2), or have not used the product. It could work as a medium that initiates conversations between people and arouses others' curiosity regarding air quality. For example, one places the Smart Air Detector in her/his office, and talks about the air quality in the place. The user could spread words about the air quality and the product to her/his colleagues, and other people could get influenced by the words which likely influence the awareness of having clean air. Considering that having awareness is the first step for behavior change as the researches had defined before (See 2.1.2.1 Motivation; 2.1.3.1 Unawareness; 3.4.2.2 Awareness and Motivation), the additional values in storytelling for others could be influential. The detailed scenarios regarding it will be illustrated in 5.1.4 Behavior Changes.

5.1.3.2 PHILIPS SMART AIR - MOBILE APPLICATION

The new proposal of a Philips Smart Air - mobile application, works together with the Smart Air Detector. When the Smart Air Detector collects air data and visualizes it on the product, the data also goes to the users' mobile application, so that people can monitor details with more tailored and doable insights based on their contextual differences along with developing their own motivation constantly.

The prototype of the renewed Philips Smart Air is available at:

https://invis.io/5N7WX5HE7

APP STRUCTURE

The structure of the mobile application mainly consists of five menus: Dashboard, Insights, Health, Filters and Profile (See Figure 43). Along with it, there is also a Control panel – allowing users to remotely control their air purifiers, and Settings – for adjusting to diverse options.

UI DESIGN

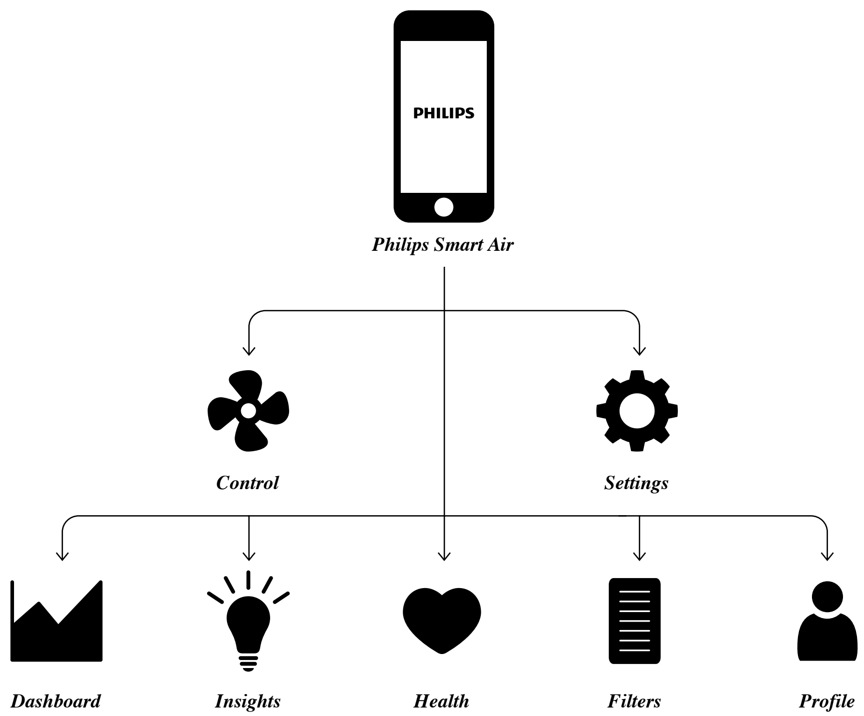


Figure 43: <App structure>

ONBOARDING PROCESS

Providing right default options by identifying one's motivation level and contextual differences is the goal of the onboarding process. Based on the results of the identification process, the system can categorize one's motivation level (See Figure 45), and suggest the first tailored default option providing relevant contents and quantity of information – "persuasion through customization" (Fogg, 2003, p. 37-40), for diverse user groups (See Table 5). Finding the right default option from the beginning is imperative, since people show a tendency that they usually go along with the first default option – "status quo bias: a fancy name for inertia" (Thaler and Sunstein, 2009, p. 19). Consequently, if a service conveys a wrong default option to users, it would ultimately induce bad decision making.

As the first step of the onboarding process, the application asks initial questions: health issues related to air quality (5), vulnerability of family members (4 to 5), home location (3) and so on. Throughout this process, the system analyzes the users' needs and contexts and provides relevant services, e.g., when one has a 12-month old baby in their house, s/he could get tailored information for the baby regarding air quality.

For the next, the application suggests variable functions that users can access after the onboarding process (6). Basically it is divided into three options: Simple, Moderate and Detailed, and users can optionally choose a specific function, e.g., current indoor and outdoor air qualities, air data history, air maps and so on. The system also advises "the most preferred" suggestion that contains popular functions by other people who are living in the same neighborhood or country. Since people want to know what other people do – "social comparison" (Fogg, 2003, pp. 198–199), so it can nudge users by telling them what others' previous choices were in the same environmental context (Thaler and Sunstein, 2009, p. 75).

The final page of the onboarding process shows a congratulatory message as a reward (8). By applauding users for the first successful action, the system could encourage users to go to the next step (Eyal, 2014, pp. 95-133; Fogg, 2003).

In general, to successfully involve users in the onboarding process, a consecutive tunneling method was mainly used for figuring out one's contextual backgrounds without reluctant feeling during the process (Fogg, 2003, pp. 34–36).

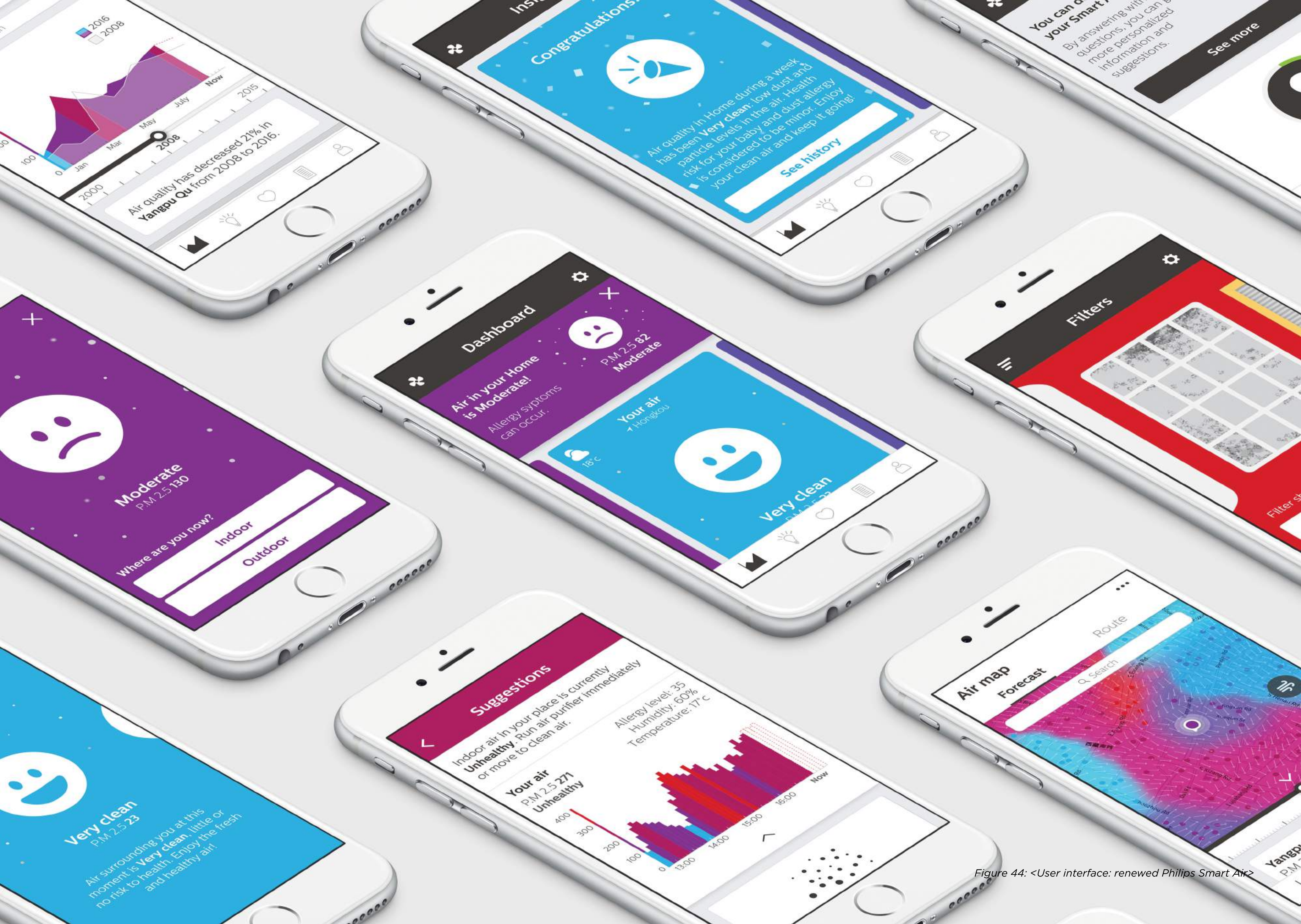
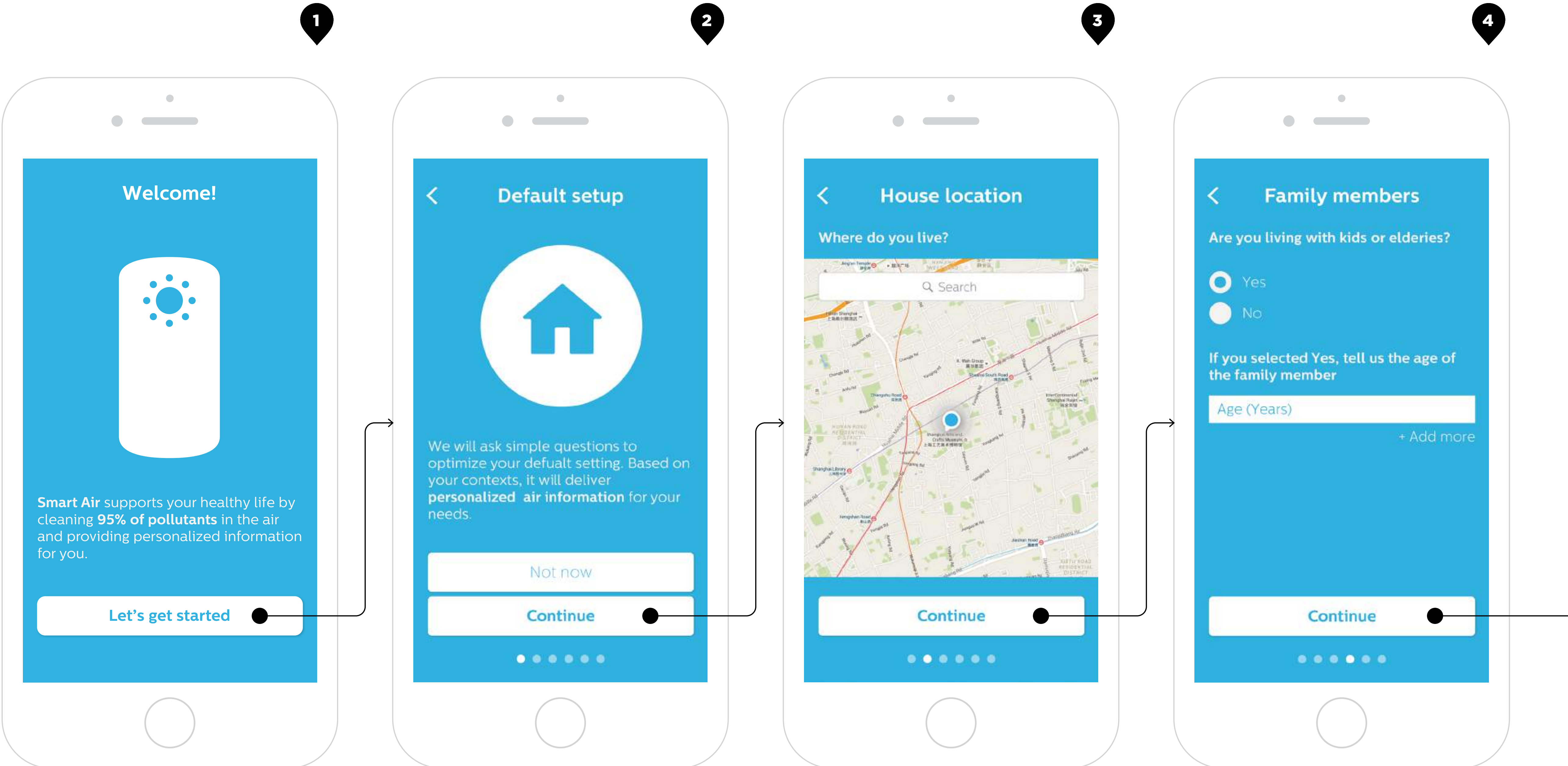


Figure 44: <User interface: renewed Philips Smart Air>

Figure 45: <Onboarding process>



WELCOME PAGE

Starts with an animation illustrating the changed air quality by cleaning dust in the air.

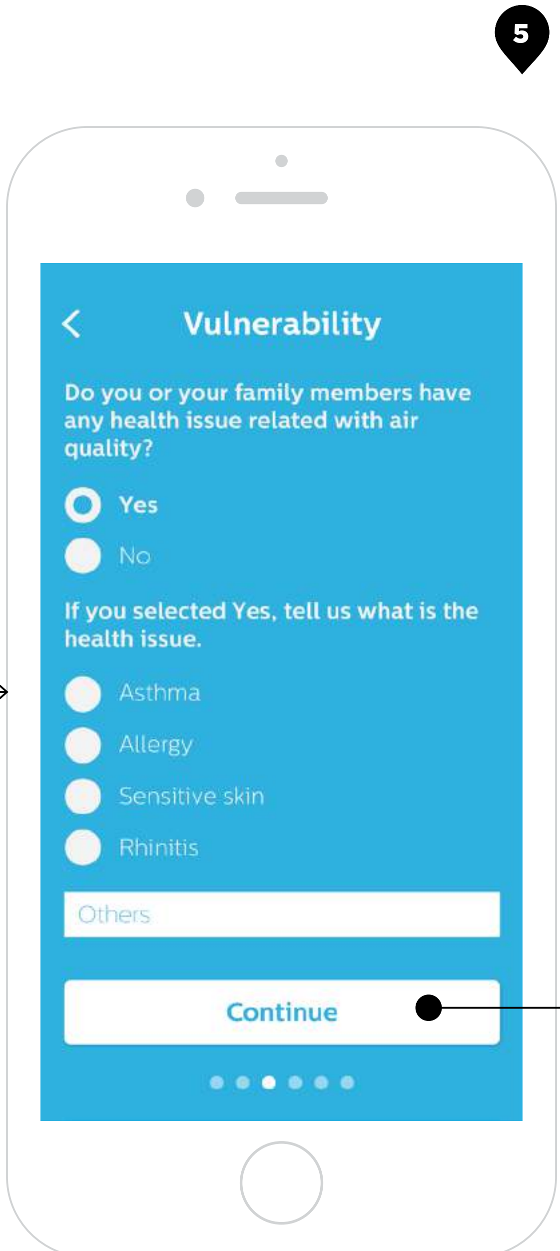
DEFAULT SETUP

HOUSE LOCATION

Initially shows the current location through GPS.

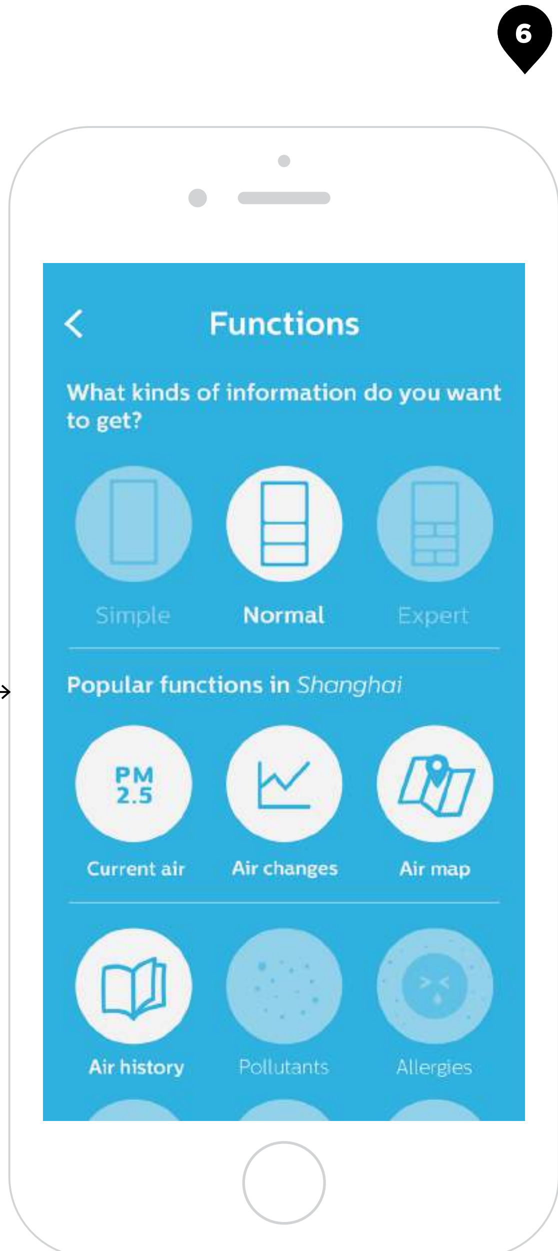
FAMILY MEMBERS

Asks family members and their age to contextualize information.



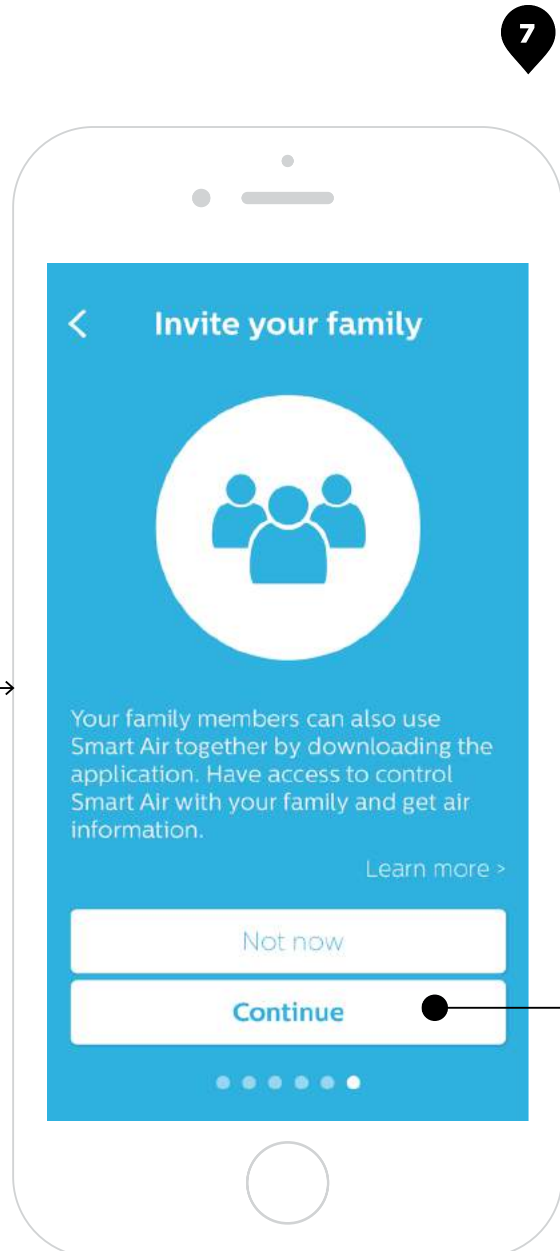
VULNERABILITY

Asks health issues related to air quality.



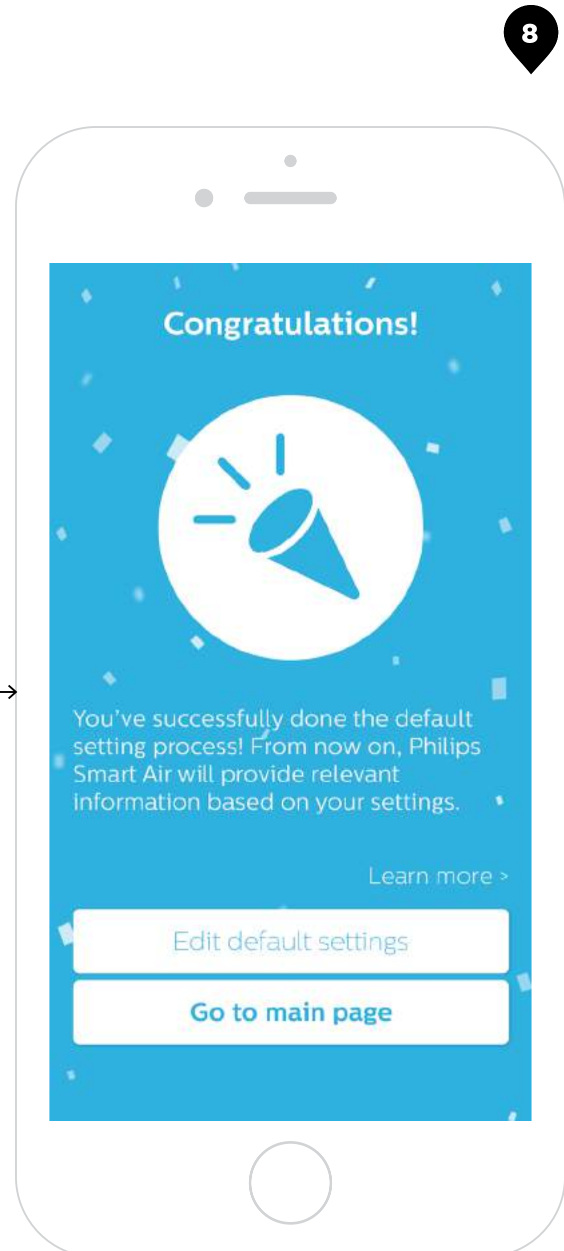
FUNCTIONS

Selects functions for tailored default setup. The application suggests popular functions in a context.



INVITE FAMILY MEMBERS

Others can also access to the air data and control the air purifier.



FAMILY MEMBERS

Computer applauses user's first achievement.

DASHBOARD

Users could land to the main page consisting of different data visualizations after the onboarding process. For initial users, the system explains the meaning of each icon and the ways of using the application to make it easy to use.

1) Notification Bar

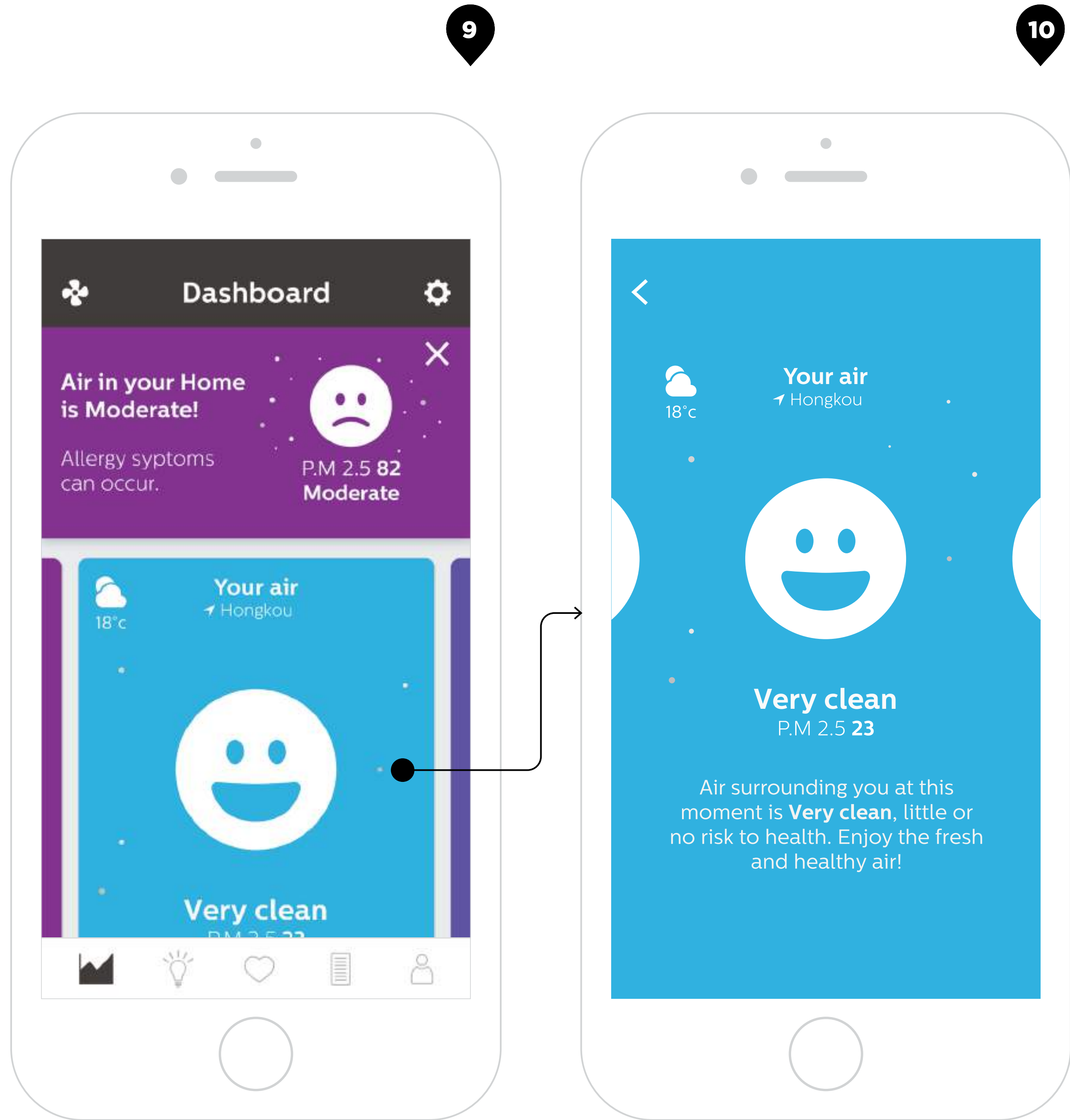
On the top of the dashboard page, users can see a notification bar highlighting important information that users might consider and asking questions for further personalization of the service (See Figure 46 (9)). It is efficient not only to catch the users' initial attention – increasing awareness, but also to make them engage more in using the product with persistence (Fogg, 2003, p. 216). For example, the application tells that "Did you know that? Generally indoor air quality is 2-5 times worse outdoor.", which can instantly increase the users' awareness through breaking the common perception regarding air quality. It can also ask "How big is your house?" or "Do you want to know more about health impact of bad air quality?" This would ultimately persuade users to use the product more by stimulating their curiosity. Figure 46 shows an example when one is outside of her/his house, the app shows that the home air quality is moderate, but the current air surrounding the person is very clean.

2) Current Air

The current air section that consists of Your air, Home air and Outdoor air illustrates air qualities via emoticons, colors and texts (See Figure 46 (10)). It intentionally minimizes the quantity of arbitrary symbols: texts and numbers, and emphasizes graphical elements to bring quick understanding about air quality (See 5.1.2 Subordinate concepts).

In terms of behavior change, the visualization provides simulated environments so that users can experience the hypothetical air quality just like the visualization in Smart Air Detector (See 5.1.3.1 Smart Air Detector). In detail, the dust animation illustrating floating dust particles in the air could convey a simulated air quality of a place, so people could naturally interpret the level of air pollution in the place. It also illustrates the process of cleaning air on Home Air through the simulation. By simulating the process of cleaning dust in the air – absorbing dust particles, users can experience the virtual results of cleaned air (Fogg, 2003, p.61-87).

Figure 46: <Notification bar and Current Air>



NOTIFICATION BAR

Illustrates important information and asks questions for personalization.

CURRENT AIR (TAPPED SCREEN)

Shows Your air, Home air and Outdoor air. When it is tapped, one can see details for selected category.

3) Data Visualizations: Air Surrounding You, Air Map, Air History and Pollutants

Under the Current air, users can have access to various data visualizations that have been initially defined through a default option during the onboarding process (See 5.1.3.2 Onboarding Process). Throughout the data visualizations, it allows users to do self-monitoring for the changes of air qualities (environmental contexts) and their behaviors, which can role as variable rewards (Eyal, 2014, pp. 95–133). By monitoring it, users can understand changes happening around them, increase their awareness about air quality and their behavior and re-adjust the options about the product to make it more efficient (Tikka et al., 2016).

In detail, Air Surrounding You (See Figure 47 (11)) illustrates historical data of air quality based on the users' locations.
On the Summary, users can see how much clean air they have had at different locations with a glance.
On PM 2.5 section (11), users can check the changes of PM 2.5 in different locations based on their time period: daily, monthly and yearly. Under the graph, people can compare their clean air consumption in comparison with other people and other countries – social comparison (Fogg, 2003, p. 198-199). By knowing how much they are better or worse than the average, they could get satisfied with the results as rewards or have more motivation to achieve cleaner air.

Air Map (12) combines real-time air data from the Smart Air Detectors of individual users and public API. It visualizes the data through a color map with a wind map that make people easily recognize the air quality in a vast area and the changes in it.
On Forecast, users can see the anticipated changes of air quality based on a timeline through a color map and a bar chart.
On Route (13), users can see the analysis of one's daily route. The frequency of one's route is visualized through the thickness of path. Not only analyzing one's commute, but it also suggests the best commute to a targeted location e.g., office. When one tries to search the best route, for example, the application finds the cleanest commuting route based on different modes of transportations: by car, bus, metro, walking and bicycle.

Air History illustrates the historical air quality data based on different air pollutants: PM 2.5, PM 10 and O3. The line chart shows the changes of PM 2.5 between 2008 and 2016 in Yangpu Qu, Shanghai, for example, and users are allowed to compare the current year with other years (14).

Pollutants (15) shows one's air pollutants that have accumulated over time. Users can put the data by themselves when the application asks a situation, e.g., when the Smart Air Detector finds home air quality is unhealthy, it would ask the anticipated reason of the situation. By collecting these data, the application can deliver useful insights, e.g., if one has unhealthy air quality often because of ventilation, the application can trigger the user to open windows when the outdoor air quality is clean enough.

INSIGHTS

Insights gives opportunities utilizing the collected data sets: from users, behaviors and environments (See Figure 48), and transforms it to a doable behavior suggestion for individual users. Due to the complexity of understanding data visualization in the Dashboard, the Insights gives more understandable, actionable and digestible information to users.

In detail, on the Summary section of Insights (16), the application applauds the users' achievement about having clean air. The congratulatory message could encourage users to keep having clean air and motivate them even more (Eyal, 2014, pp. 95-133; Fogg, 2003, p. 102).

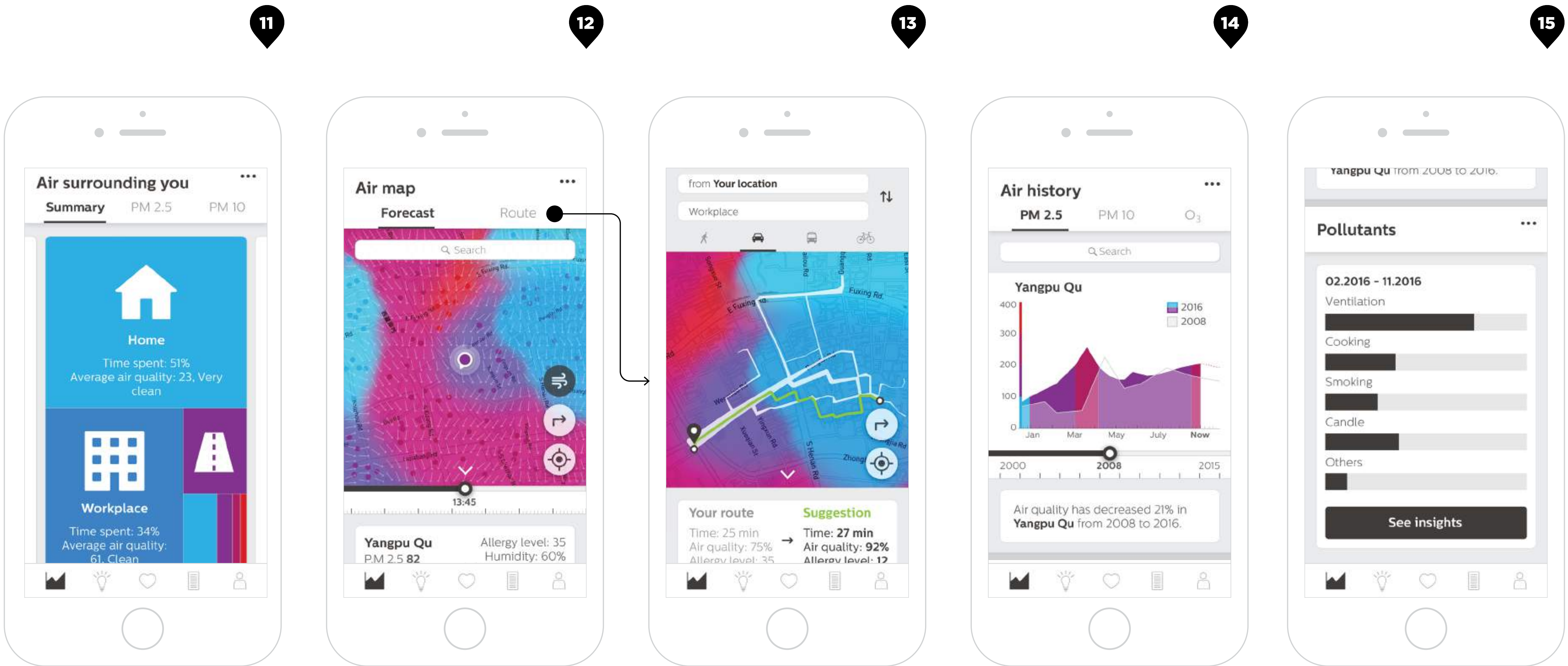
In Suggestions (17), it delivers tailored and doable suggestions to users. For example, the system reflects the location of the user's home and outdoor air quality, and it provides a suggestion notifying proper timings of opening windows in one's neighborhood. If the user has a baby, it can also suggest avoiding outdoor activities with the baby when the outdoor air quality is going to be unhealthy. In addition, it can also recommend changing one's commuting route if the ordinary route records relatively lower air quality comparing to other routes. Buttons (external trigger) in each suggestion can also guide users to a deeper layer of information that has detailed information or setting options.

HEALTH

Health conveys health information reflecting from one's contexts (See Figure 49). To increase the credibility of the given health information, the information can be provided or supported by real-life doctors who can possibly work with Philips, and give more credible and authorized health information rather than simply providing common knowledge (18). The information could satisfy trustworthiness and expertise, which are essential dimensions of credible information (Fogg, 2003, pp. 122–125).

The Health also shows simulations of health effects depending on air qualities, time, and people (19). Users can freely adjust those options and can check the anticipated health effects with detailed descriptions. In addition, health information is constantly updated based on data collections and the changes of the users' contexts, so that users can get a more personalized health information.

Figure 47: <Data visualizations: Air surrounding you, Air map, Air history and Pollutants>



AIR SURROUNDING YOU

Illustrates historical data of air quality based on users' locations.

AIR MAP

Visualizes air qualities on a map, and users can see air forecast by scrolling the time bar.

AIR MAP - ROUTE

Suggests cleanest commuting route for targeted location, e.g., office.

AIR HISTORY

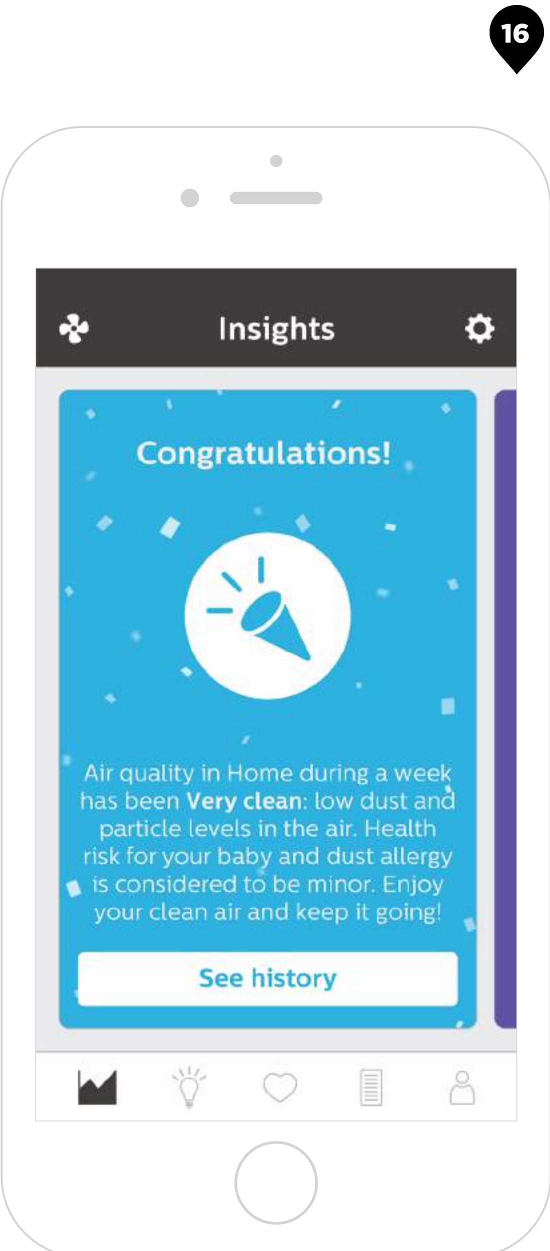
Shows historical the changes of outdoor air quality for longer period of time.

POLLUTANTS

Indicates the list of pollutants that one has had. Based on the collected data, system delivers actionable insights.

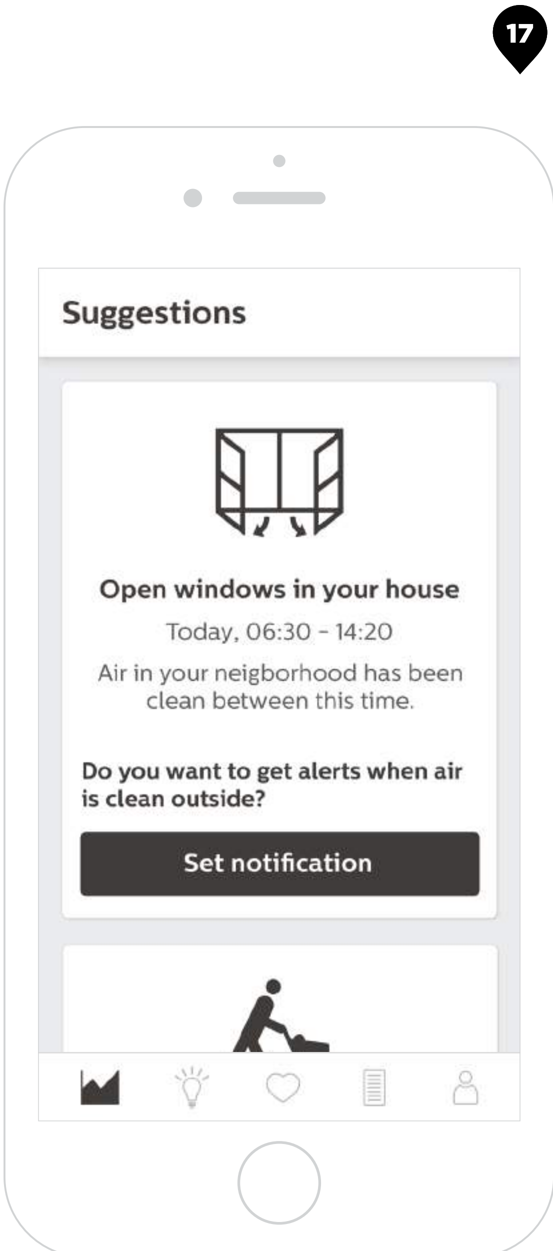
Figure 48: <Insights>

Figure 49: <Health>



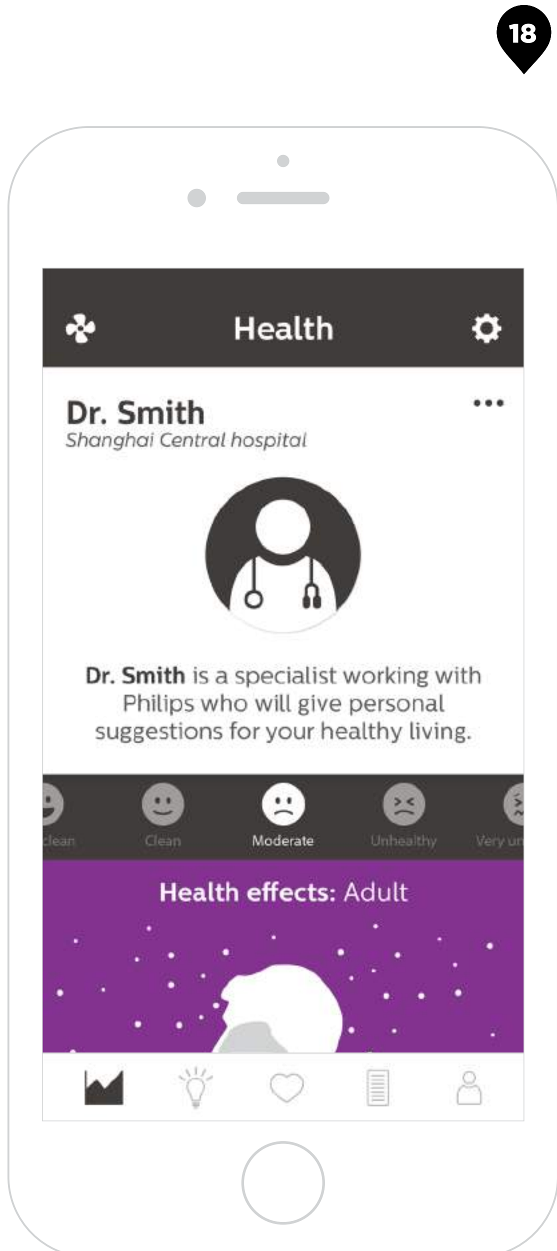
INSIGHTS - SUMMARY

Understandable and digestible insights based on collected users' data.



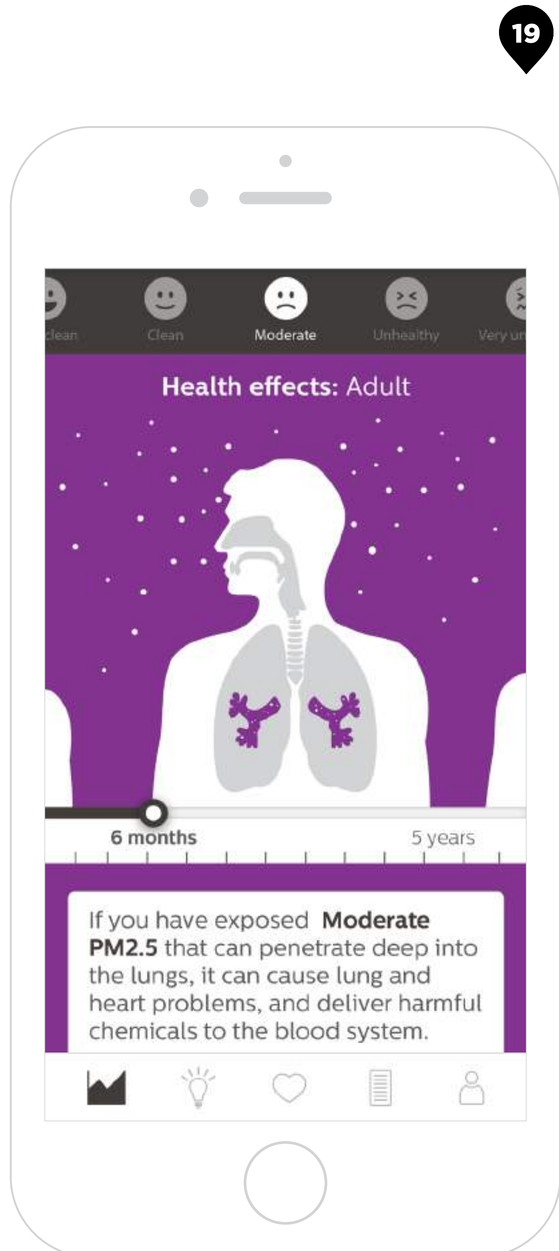
INSIGHTS - SUGGESTIONS

Suggests actionable insights reflecting one's contexts.



HEALTH - DOCTOR

Health information reflecting one's contexts. The information of doctor aims to give more credibility of delivered information.



HEALTH- HEALTH EFFECTS

Shows anticipated health effects based on one's age and different air qualities.

FILTERS

Filters visualizes the status of collected dust in the Philips Smart Air Purifier (20). The visualization of collected dust could act as a strong persuasion by delivering negative and positive messages to users (See 3.4.4 How to Enhance Experience: Visualizing Air). In terms of the negative meaning, users can directly recognize that the filter is dirty and dusty, which arouses uncomfortable feelings that could persuade users to clean or buy new filters. At the same time, users could have the feeling of satisfaction, since the collected dust represents the work performance of the product, i.e., the collected dust was in the air, and the air purifier has filtered all dust effectively. Consequently, the graphically illustrated dust visualization can act as a medium bringing emotional interaction.

PROFILE

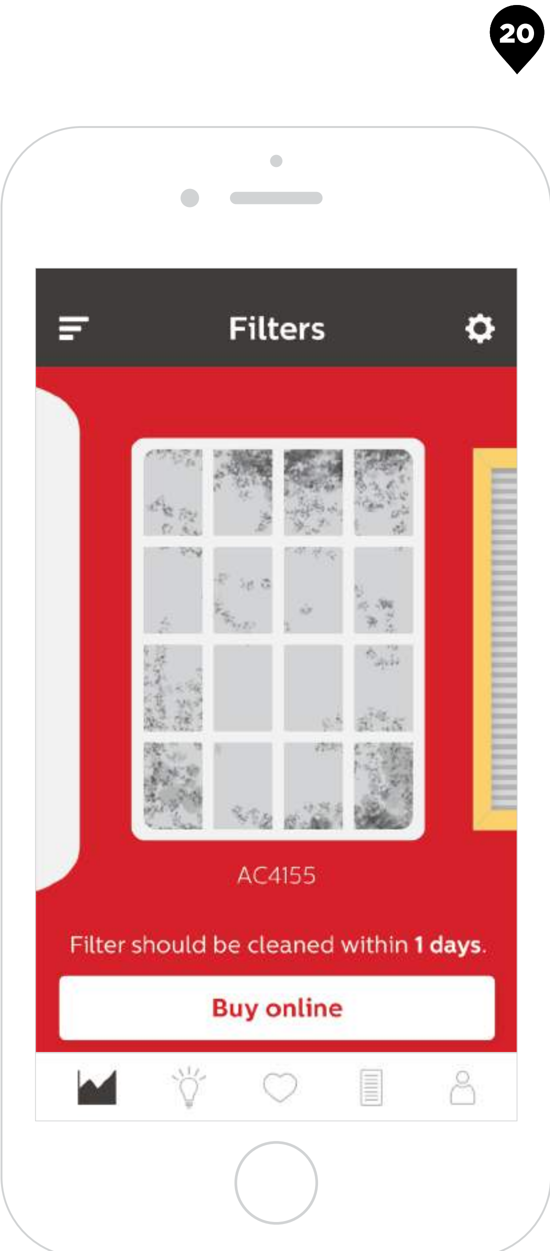
Profile shows the registered personal and contextual information: home location, workplace, health vulnerability, family and so on (See Figure 50 (22)). In terms of building habit-forming products, this page would work as 'investment' in the Hooked cycle (See Figure 6). Users are constantly encouraged to invest their time and effort by visual stimulus: completion rate of one's profile and questions in the Notification bar in Dashboard (See 5.1.3.2 Dashboard). Especially, by utilizing the heuristic in the profile status (21) – the endowed progress effect, users would be more aware and motivated, and they finally invest their time to make it close to '100%' (Eyal, 2014, pp. 89–91).

CONTROL

Control allows users to remotely control their air purifier via smart phone with the visualization of the current home air quality (See Figure 50 (23)). As like other visualizations, it also delivers the dust animation with colors exhibiting the status of indoor air quality. Moving circles around the power icon in the middle of the screen represents a status that the air purifier is working and cleaning dust in the air.

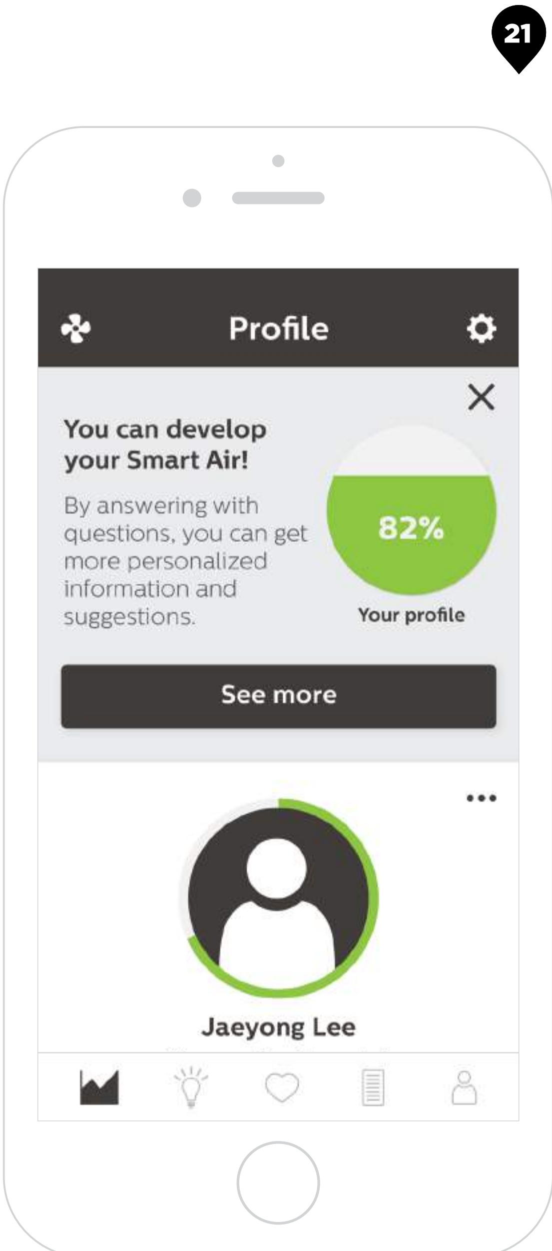
The process of cleaning dust is emphasized due to the uncertain result of purification; people could not feel the clear results after using air purifier (See 3.4.1.2 Findings and Insights). To maximize the virtual experience of cleaning air, the Control displays an animation sucking dust particles that would provide cause-and-effect simulations (Fogg, 2003, p. 63). Users could visually see the process of cleaning the air, and the result of purification: cleaned air without dust particles, would acts a reward of the behavior using an air purifier (Eyal, 2014, pp. 95-133).

Figure 50: <Filter, Profile and Control>



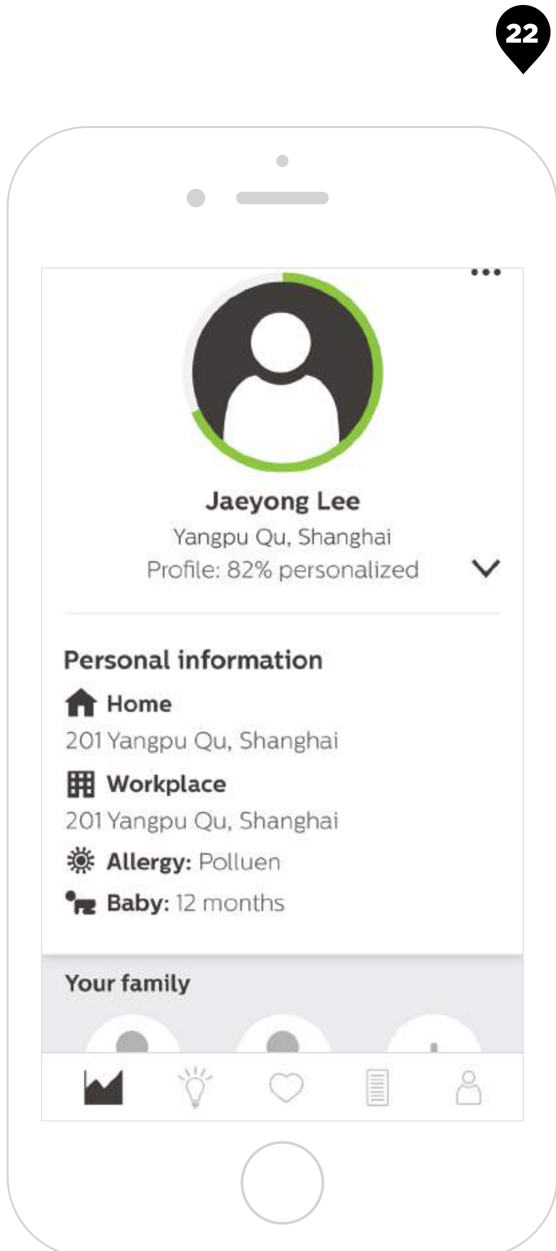
FILTERS

Visualizes the status of collected dust in the filters.



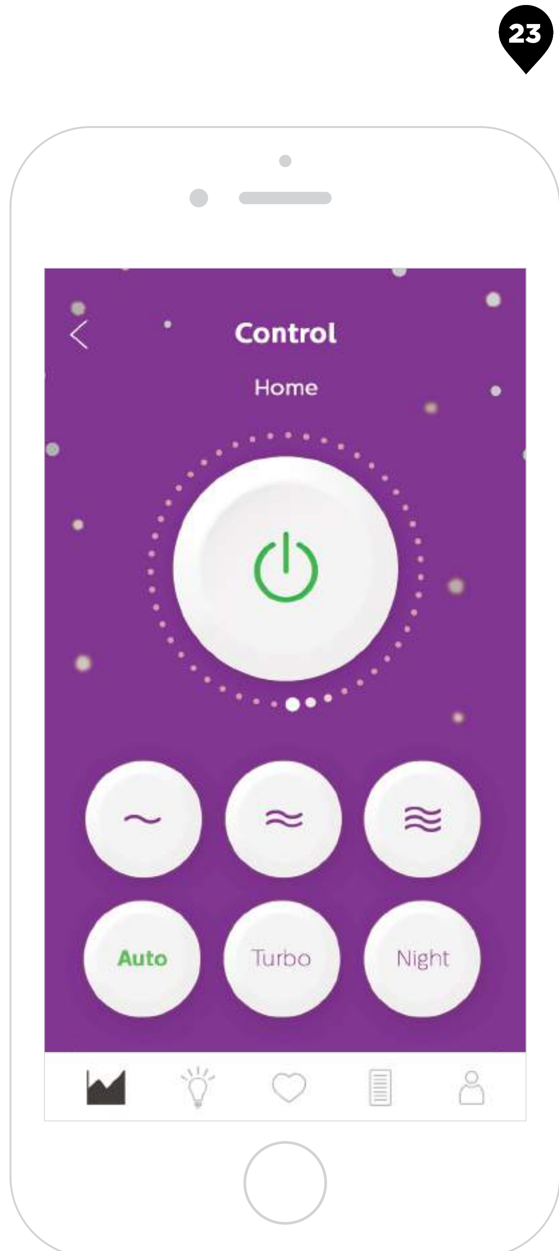
PROFILE_1

Encourages to complete the profile setup - investment.



PROFILE_2

Shows registered personal and contextual information.



CONTROL

Enables to control air purifier and deliver the experience of the current Home air.

5.1.4 BEHAVIOR CHANGES

As selected target behaviors defined (See 4.4.6.1 Selected Target Behavior), the design outcomes were applied on intervening the users' behaviors in specific contexts. The interventions that are described in this section were already examined via the 2nd user evaluations through the result of the 2nd iteration design, which is nearly similar with the result of final design outcome. (See 4.4.8 Evaluation #2). Stories in this section reflected the actual evaluators' opinions, and a defined user persona: Veera (See 4.4.3 User Personas) who represents User Group 2 (See 4.4.2 Target User Group), was used for explaining the result of the 2nd evaluation through her stories. The contexts of stories are also the same with the second evaluation (See 4.4.8.1 Methods).

5.1.4.1 OPEN WINDOWS

VEERA'S STORY #1

Veera has an afternoon work shift in a coffee shop in Hongkou, Shanghai (See Figure 51 (1)). The café usually is full of coffee aroma every day, and there are many customers in the place from morning until evening. Before using Smart Air Detector, she just assumed that the air quality seems not so good in the place, and she did not know what she can do to make clean air. There are ventilation fans on the ceiling, but she couldn't be sure whether it efficiently cleans the air or not.

During her work, she sees that her Smart Air Detector on the wall shows vigilance emoticon: moderate air quality (2), so she opens the mobile application to check air quality of the place (3).

She sees that the indoor air quality in the café is moderate. As the application asks 'where are you now?', she pushes the 'indoor' button.

She sees a page of suggestions. She can check a simple description of the current air status, an air map showing the air quality of the nearby place and the changes of air quality in the café during 4 hours. Below that, she can see possible behaviors that she could consider to do. She thinks that she can probably open windows, since the application says that the current outdoor air quality is very good (PM 2.5 12).

When she reached the Open windows page, she could see a clear explanation how long time she needs to ventilate the air based on the outdoor air quality of the neighborhood (4). She understands that it is good to ventilate air for a while, and then she decides to open windows (5). She pushes the 'Okay' button.

Windows have been opened for 30 minutes, and the Smart Air

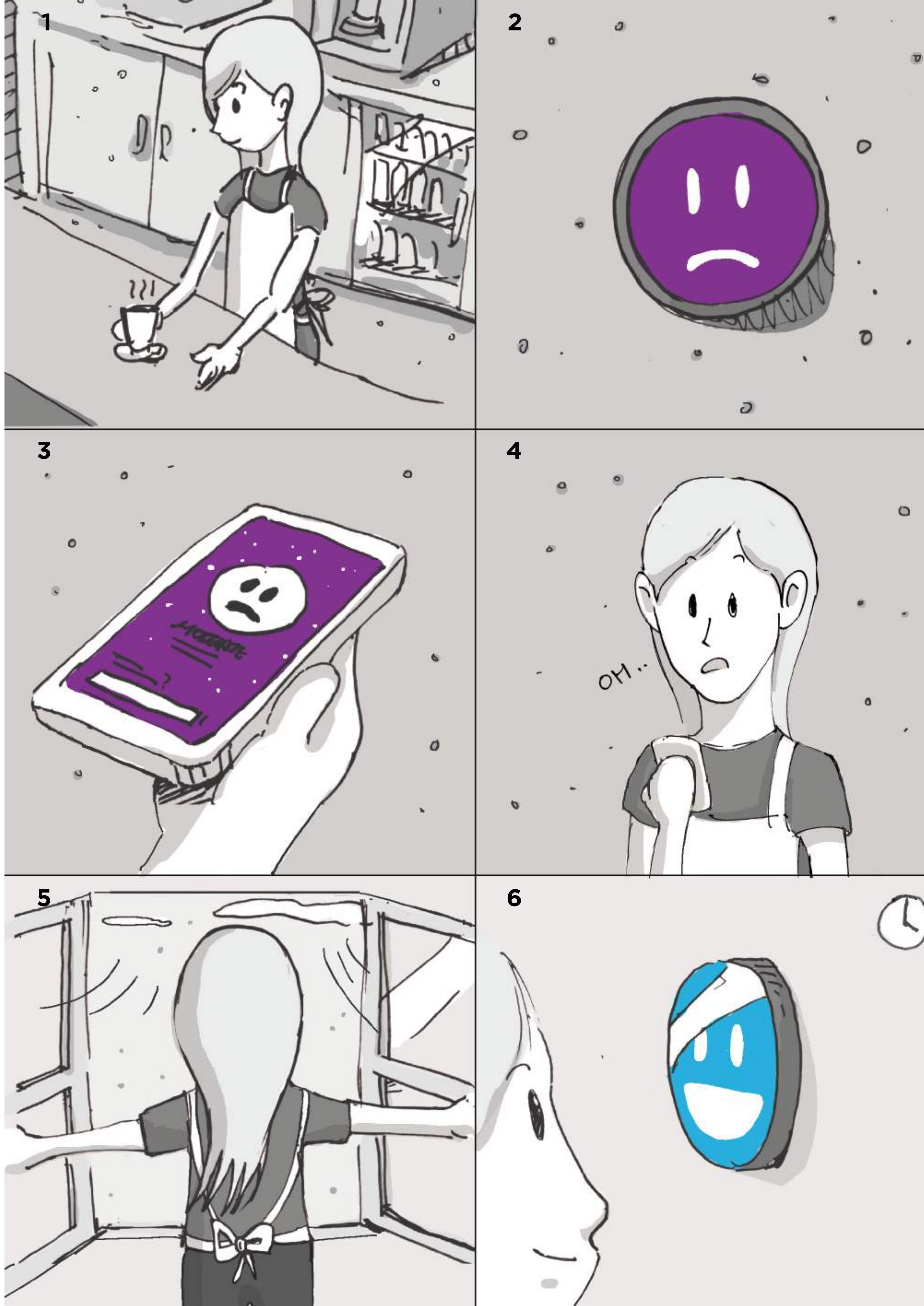


Figure 51: <Veera's story #1: Open windows>

Detector also shows a serenity emoticon (6). Since she was busy for doing her job, she could not see the changed emoticon on the device. Later, she found out that there is an unread message on the application. She opens the application, and it shows the message 'Your air is clean now.' It also asks possible reasons for the previous moderate air quality, and she thinks that it was because she did not do ventilation for a while. She selects ventilation as the reason, and the applications records the data. Application shows collected pollutants data, and guide her to more personalized insights.

ANALYSIS OF VEERA'S STORY #1

To analyze the stories from the behavior change point of view, elements in the adapted behavior model (See figure 20) and the Hooked cycle (See Figure 6) were used.

In the previous story, Veera had assumed that the air quality in the place would not be very clean. Nevertheless, she did not do any action for improving the air quality in the place. Since she did not have any clear awareness regarding the air quality, she had a low motivation level for having clean air in the specific context.

Smart Air Detector delivered an external trigger to Veera by communicating the current air quality (See 2.1.2.1 Trigger). The visual representation through Smart Air Detector was a cue for an initial action: checking mobile application (Eyal, 2014, p. 58), and increasing awareness regarding air status at that moment. When she opens the mobile application, it delivers a full sensory stimulus: dust animation, emoticon, color and big button, which intervenes to increase Veera's awareness and motivation (See Figure 52 (24)).

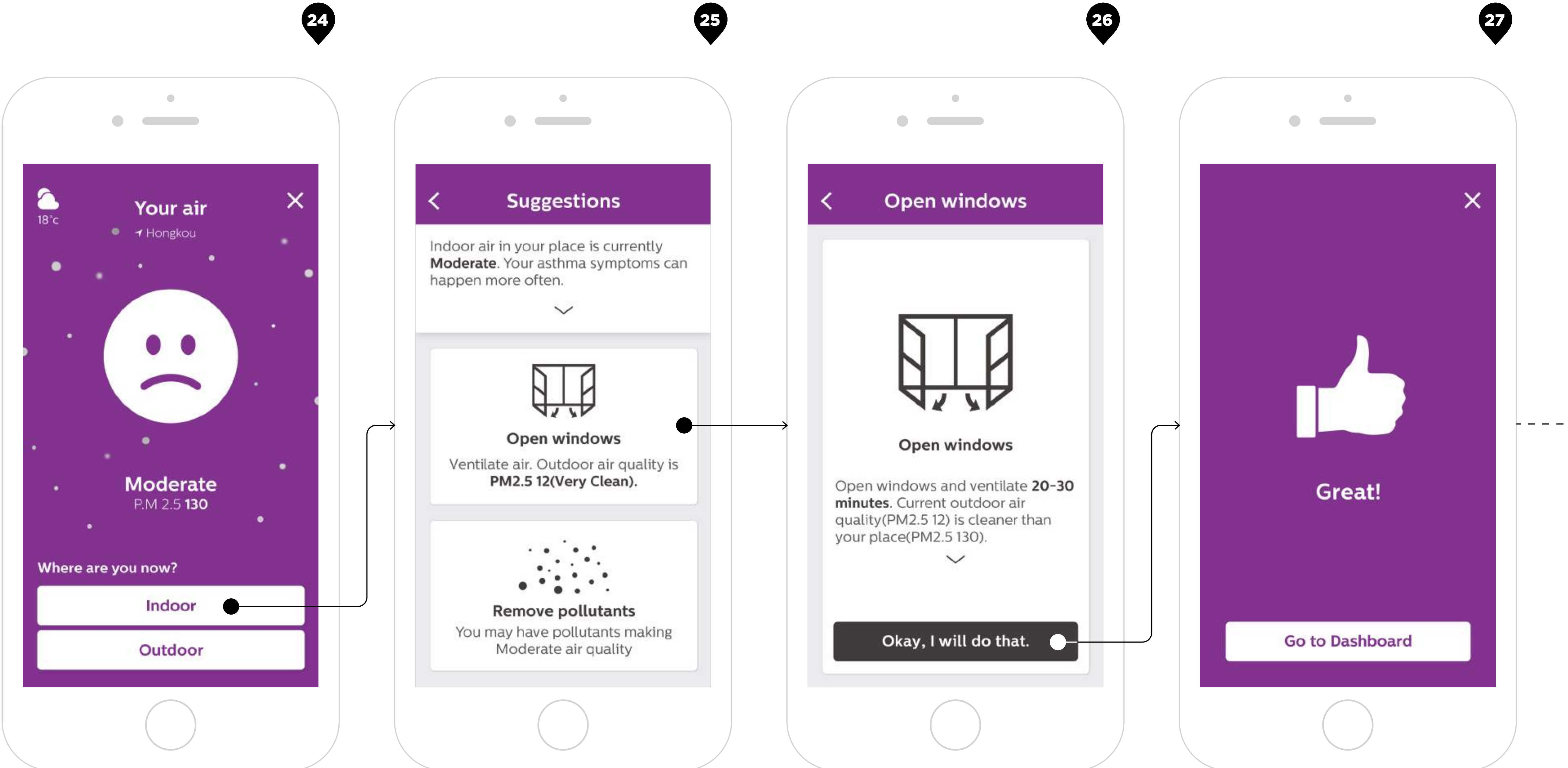
While the application uses consecutive tunneling technology (Fogg, 2003, pp. 34–36) for guiding Veera to the next pages (24-26), she could develop her extrinsic motivation; she could achieve clean air by doing one of suggestions that the application asked to Veera (See 2.1.2.1 Motivation). By having extrinsic motivation, she could make an action for the intended behavior – opening windows.

After conducting the behavior, she also saw another external trigger that guides Veera to check the application once again – an unread message (28), and it conveyed rewards of the behavior that she has done – the visual representation of clean air quality with a smiling emoticon with less dusty air (29).

To get personalized insights, she invested her time to input data for possible pollutants (30). By doing so, the application could deliver tailored insights for her, which means that she could have variable rewards from the application after her behavior (31).

By cycling her initial behavior change through successive hooks, she could have internal triggers that attach to her emotion (Eyal, 2014, p. 17). She would have increased awareness and motivation through the hooked cycle: trigger, action (motivation), rewards and investment (See Figure 6), and more closely connect the products and her emotional status. For example, when she sees a moderate air quality through Smart Air Detector for another time, the negative emoticon delivers powerful internal triggers stimulating uncomfortable feelings. The internal feelings that Veera would get through accepting interventions, she likely does the intended behavior once again. Furthermore, she could develop her intrinsic motivation of opening windows, since she has experienced satisfaction as the reward of behaviors she has done. Throughout having internal triggers and developed intrinsic motivation, the interventions could more strongly influence forming habitual behavior changes – long-term engagement (Eyal, 2014, p. 85).

Figure 52: <UI design #1: Open windows>



MODERATE AIR

Smart Air Detector sends current air data to mobile, and Veera checks it.

SUGGESTIONS

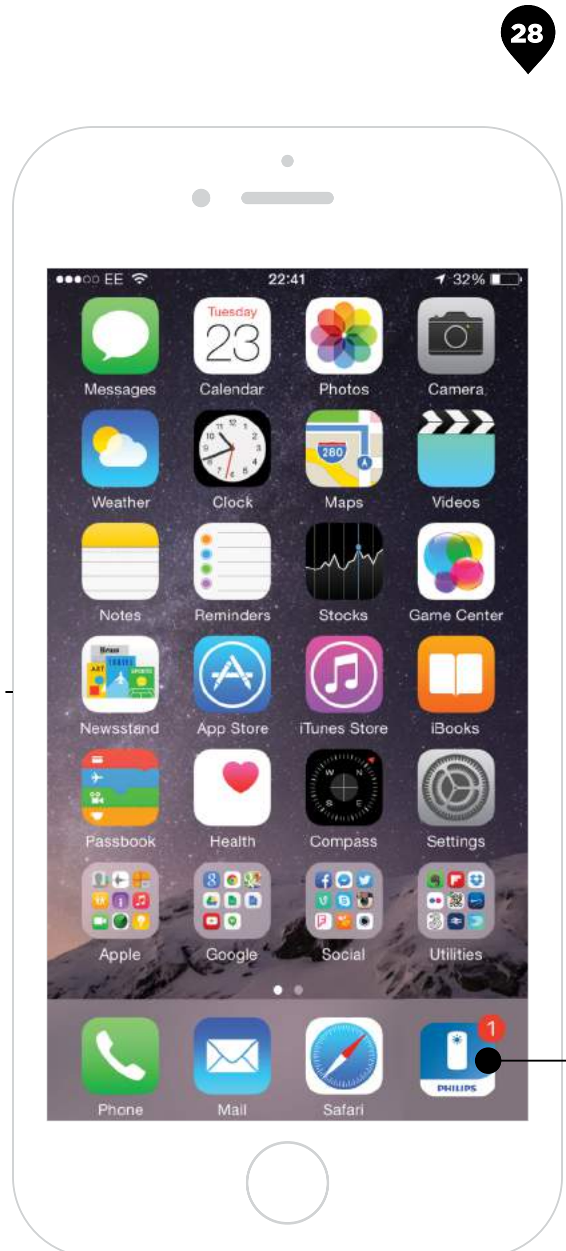
Veera can see possible suggestions that she can behave to improve air quality.

OPEN WINDOWS

The app suggests opening window by comparing outdoor and indoor air quality.

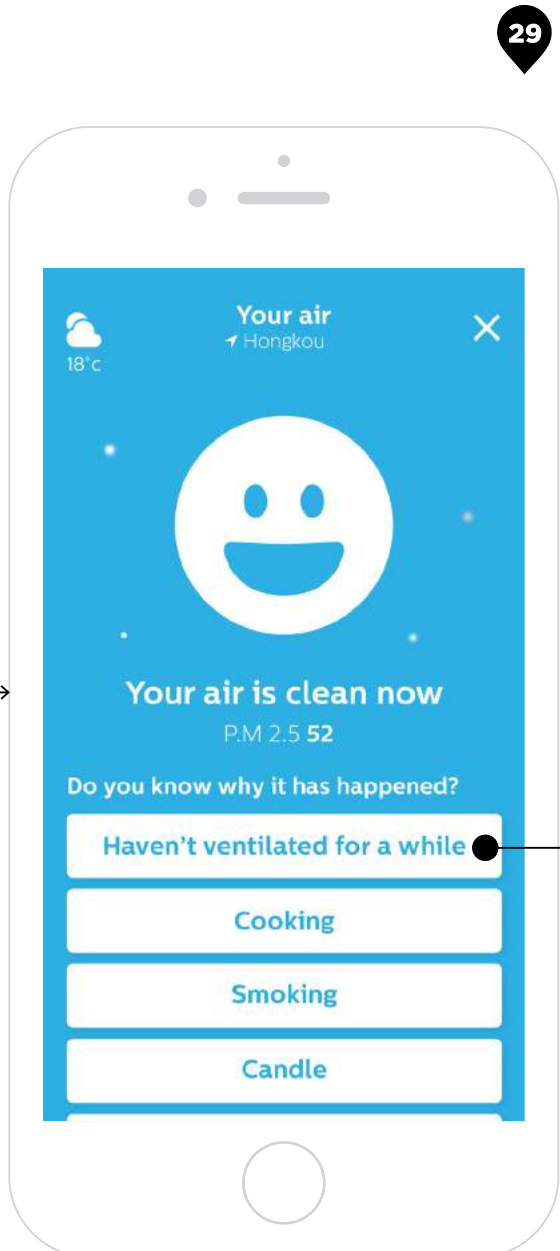
COMPLIMENT

It gives applause for Veera's choice.



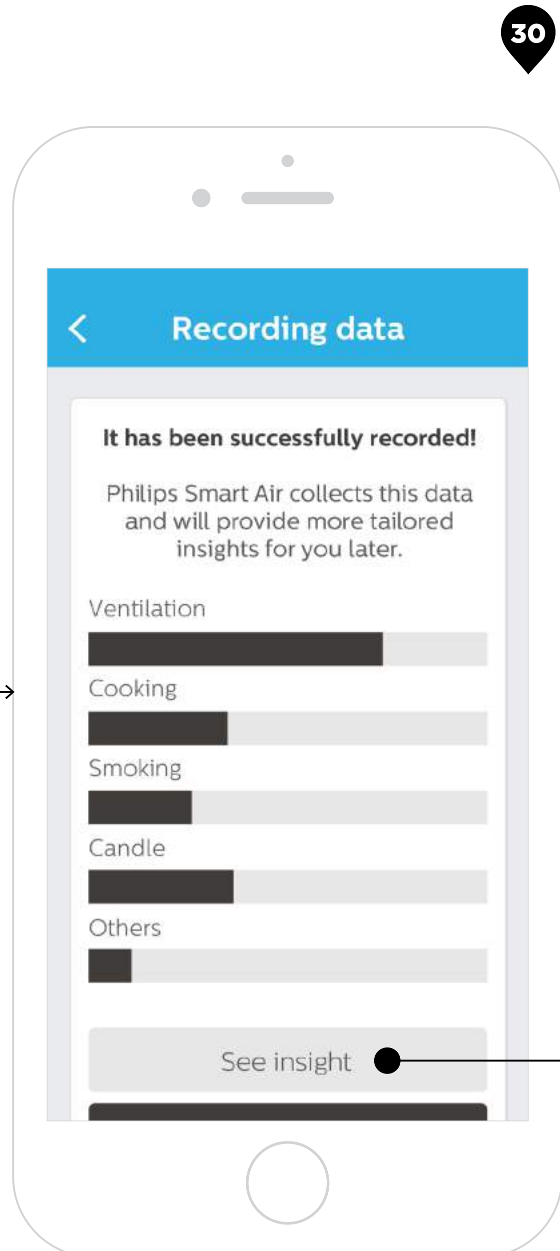
UNREAD MESSAGE

After 30 minutes, Veera finds one unread message in the app.



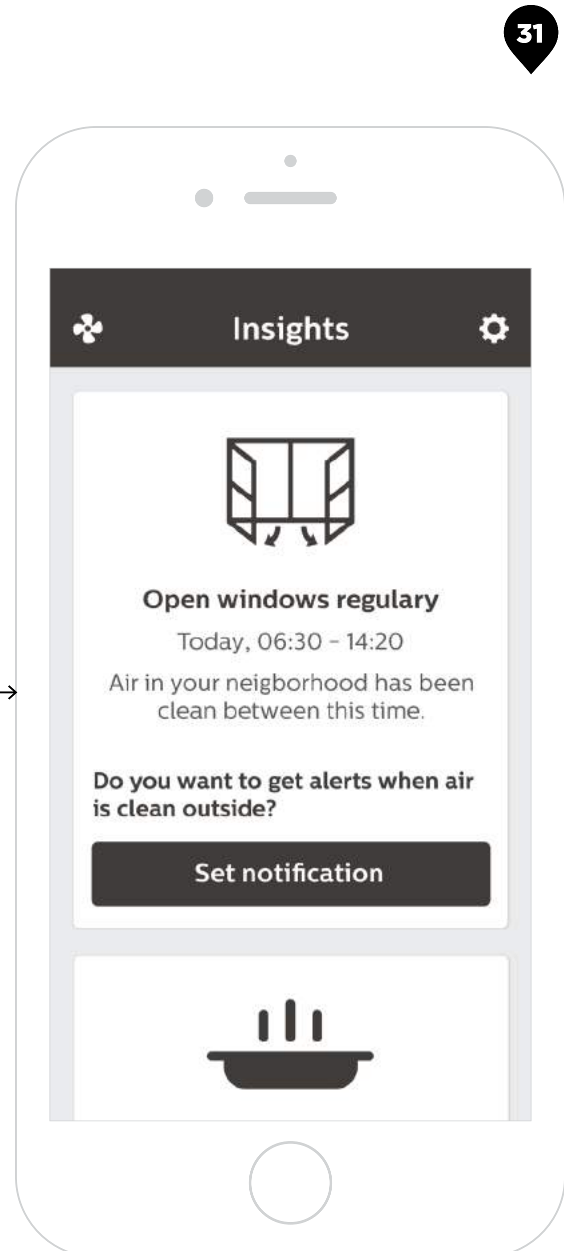
CLEAN AIR

The app lets Veera know about the cleaned air and asks the reason of bad air quality before.



RECORDING DATA

It records the data, and use it for making personalized insights.



INSIGHTS FROM COLLECTED DATA

Insights reflects collected data and give personalized suggestions, e.g., suggesting opening windows more regularly when outdoor air is clean enough.

—

5.1.4.2 BLOW OUT CANDLES

VEERA'S STORY #2

Veera and her friends are invited for a dinner in her friend's home (See Figure 53 (1)). When the dinner starts, her friend uses candles as usual. Windows are closed, 4 people are in the living room area, and people are casually talking with each other. At some point, Veera can see her Smart Air Detector that attached on her bag shows the air quality is unhealthy (2). She also gets a mobile notification for the changed air quality, so she opens the application to check details (3).

She sees the apprehension emoticon, flying dust and purple color that arouse her attention. She chooses 'indoor' button to see suggestions that she could do in the situation. The application illustrates the current status in detail and possible behavioral suggestions.

Among different suggestions, she clicks 'Remove pollutants' button. She can see possible reasons of making unhealthy air quality, and find out that the candles could be a reason.

Since it is not her home, she hesitates to blow out candles by her own decision. Instead of it, she talks to other friends that the air is unhealthy, and it could be because of the carcinogenic toxins from the burning candles (4). Other friends are interested in the topic and they start to talk about Veera's Smart Air Detector. She has used the product for a month, so she can explain how it works, and what she can do in those kinds of situations. At the end, Veera and her friends decide to blow out the candles and ventilate the air for a while (5).

After having dinner, Veera can see that the application asks the reason for the unhealthy air quality that is turned to clean status (6). As she anticipates, she chooses 'Candle' as the possible reason, the system applauses her contribution, and it collects the data for making other insights.

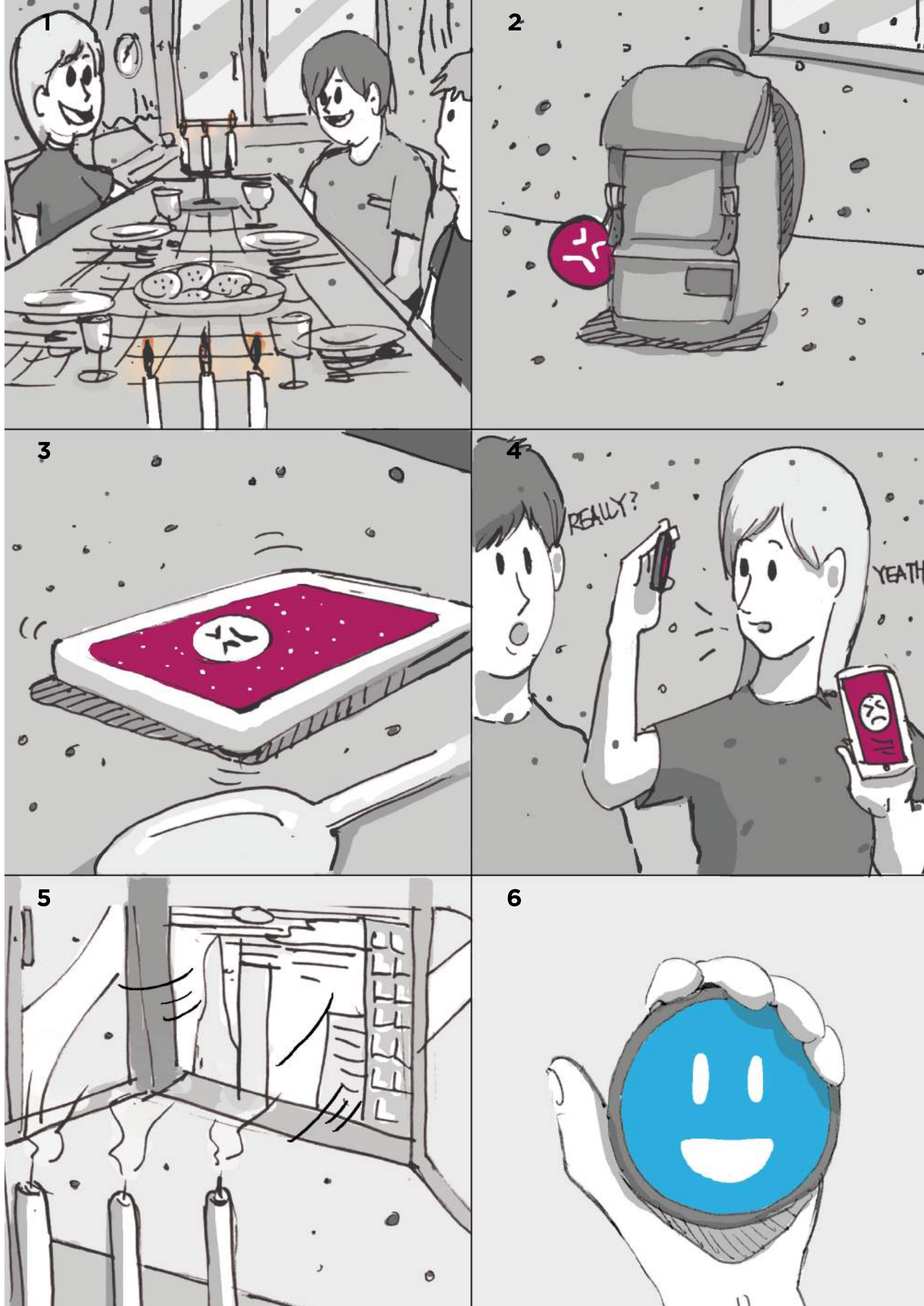


Figure 53: <Veera's story #2: Blow out candles>

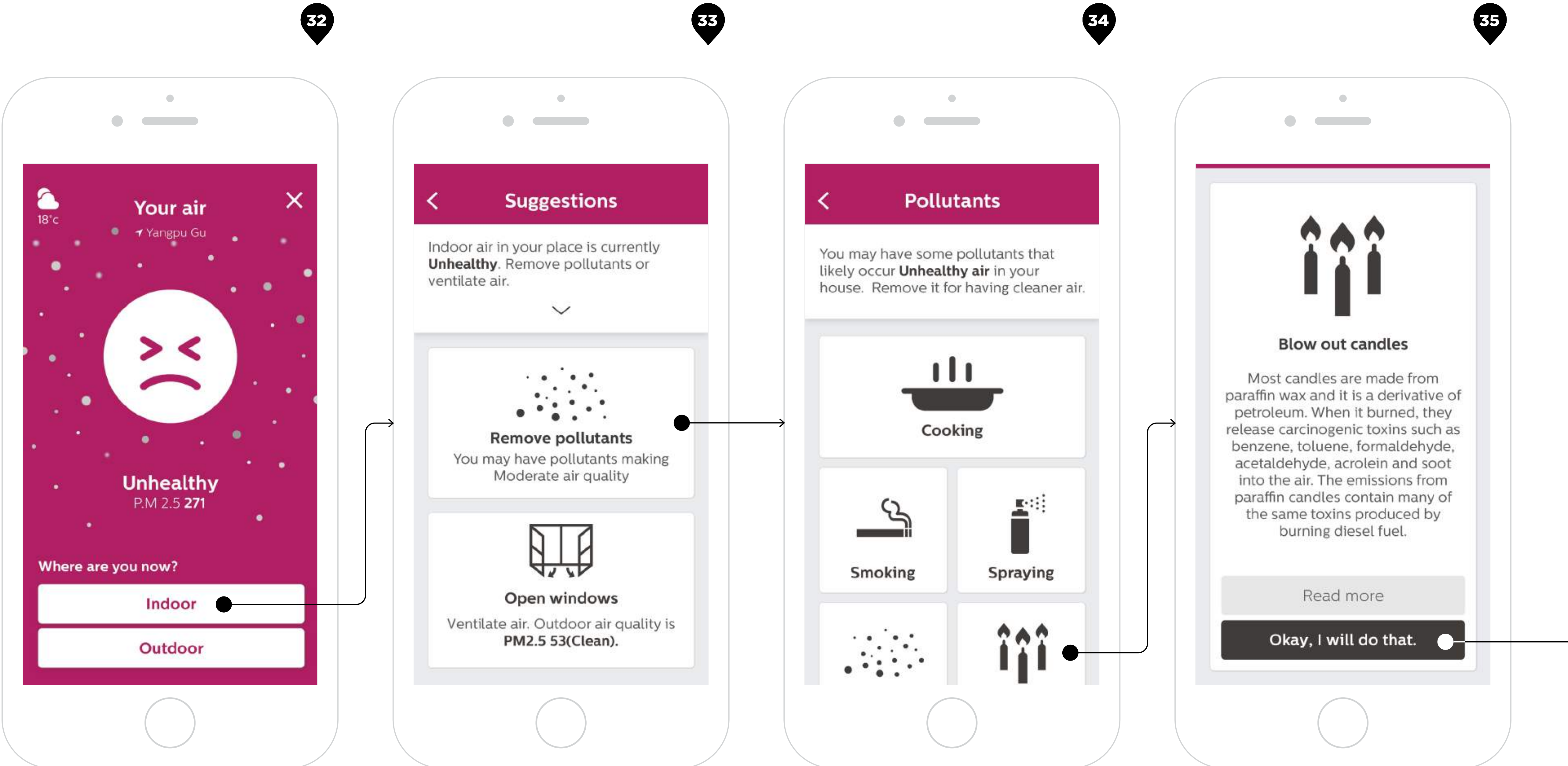
ANALYSIS OF VEERA'S STORY #2

In this context, Veera was a storyteller who initiates a conversation regarding air quality to other people (See 5.1.3.1 Storytelling for Others). In those situations, she could use the products not only for her own interpretation, but also sharing information to other people. By doing so, her friends would naturally develop their awareness and motivation about clean air, and it would guide them to consider the air quality surrounding them.

Tunneling technology guided her to reach to the right information – blow out candles (Fogg, 2003, pp. 34–36) (See Figure 54 (32-25)). External visual triggers: a changed emoticon on Smart Air Detector, a mobile alert and buttons in the application (32), influenced her to initiate a conversation with her friends (See 2.1.2.1 Trigger). Since the delivered triggers and information with the conversation that brought increased awareness and extrinsic motivation of Veera and her friends, they could decide to blow out the candles and open the windows in the context. The timing of interventions was appropriate in the context, because Smart Air Detector was able to measure real-time air data and notified to Veera by a quick-to-understand visual information.

After the situation, Veera could have instant rewards by checking the air quality that was turned to a clean status (38). She could also share the rewards with her friends; she talked the changed air quality to others The investment for getting personalized insights through recording data of pollutants was also satisfied. (See 2.1.2.2 Habitual Behavior).

Figure 54: <UI design #2: Blow out candles>



UNHEALTHY AIR

Smart Air Detector sends current air data to mobile, and Veera checks it.

SUGGESTIONS

Veera can see possible suggestions that she can behave to improve air quality.

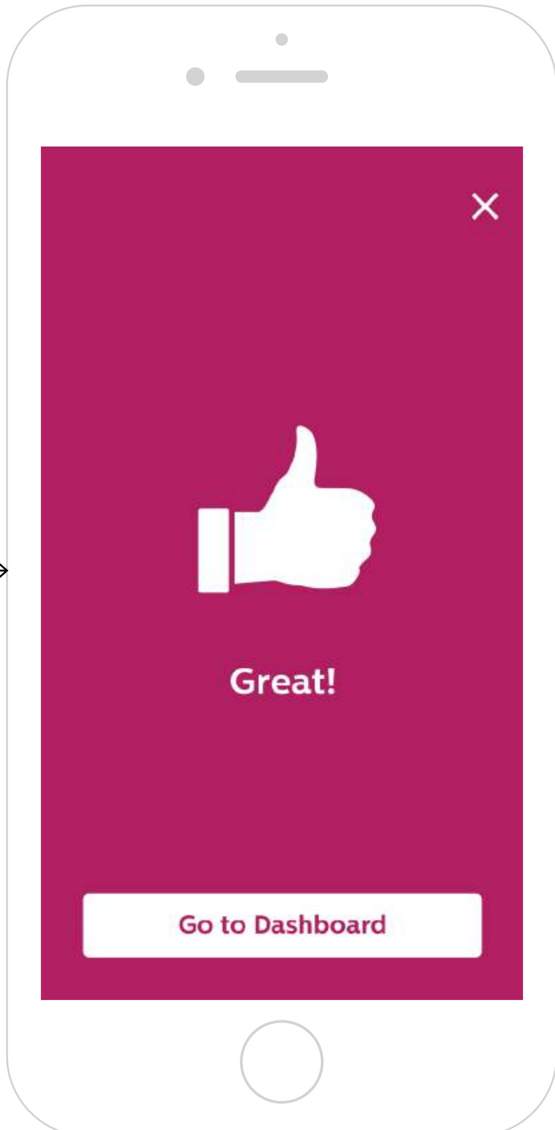
POSSIBLE POLLUTANTS

The app shows possible pollutants that likely make the unhealthy air quality, and Veera finds the candle icon on the list.

BLOW OUT CANDLES

It suggests blowing out candles if it is made by paraffin wax.

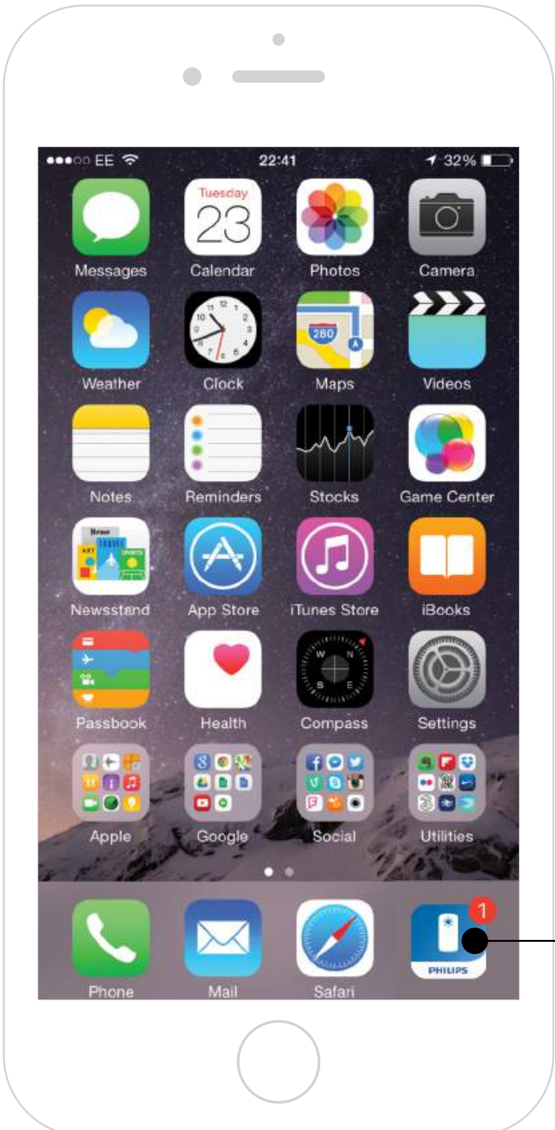
36



COMPLIMENT

The app gives applause for Veera's choice.

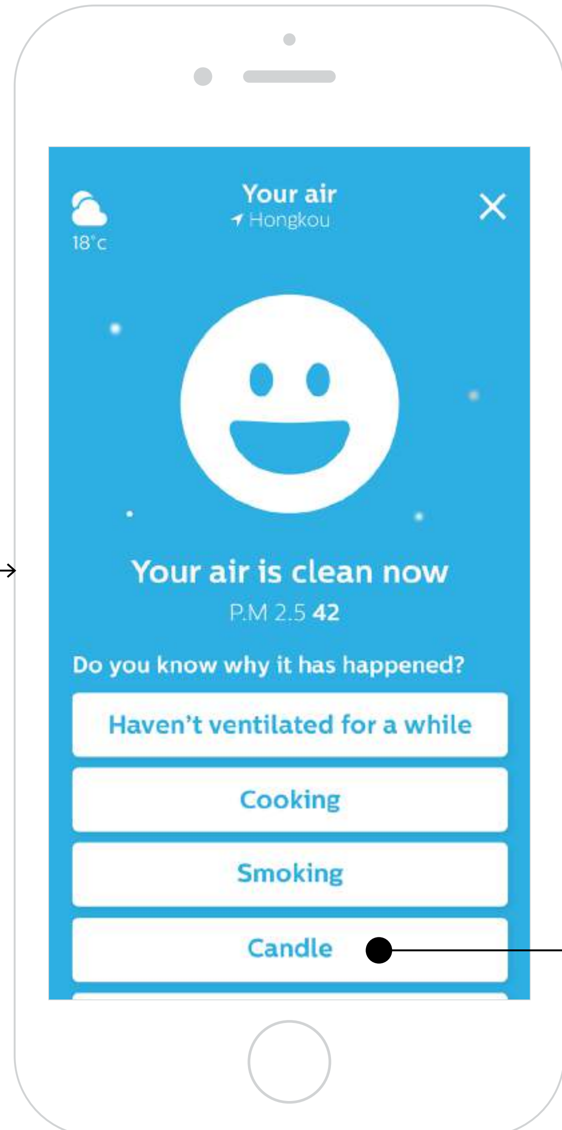
37



UNREAD MESSAGE

After for a while, Veera finds one unread message in the app.

38



CLEAN AIR

The app lets Veera know about the cleaned air and asks the reason of bad air quality before.

39

RECORDING DATA

It records the data, and use it for making personalized insights.

—

5.1.4.3 WEAR A MASK

VEERA'S STORY #3

In the morning, Veera wakes up and checks her phone on her bed. She can see that there are many notifications during the last night: Facebook, Twitter, Snapchat and so on. Among many notifications, she sees a message from Philips Smart Air Purifier application, which says that the air quality is going to be very unhealthy for today in Shanghai (See Figure 55 (1). She realizes that she should go to school for a lecture until 9:00.

She opens the application and checks the details about the air forecasting. When she notices an emoticon wearing a mask with dense dust particles with red background color in the application, she almost feels fear for the situation (2). The application indicates that the air quality would be very unhealthy from 08:00 to 20:00, with a maximum of PM 2.5 level 355. She thinks that she must do something for this situation. The application naturally guides Veera to a suggestion page and she follows it.

The application shows an air map and a bar graph; Veera could check the anticipated changes of outdoor air quality by time, and suggestions that she can consider. Veera checks the first suggestion – 'Prepare air pollution mask'. The application explains the possible influences of the unhealthy air quality on her body and different types of air pollution masks that she can use.

After understanding the information, Veera seriously considers whether she should go to school or not. Since she got basic understanding that the air quality can cause some irritation on her bronchus or a bad health impact in a long-term perspective, she is afraid to decide going school as usual. Finally, she determined to go to the school with a mask. She already puts her mask on her face before going out, and tries to not take it off until arriving at the school. When she goes out, the city was dark and dim, and she can see many people were wearing masks on the road (3). When she gets in a bus stop, her mobile notifies that her Smart Air Detector analyzes the current air quality in the location, and it is very unhealthy. The application suggests to her wearing a mask immediately, and she answers that she already wears it. It applauses her proactive behavior with a 'Great' message and a thumbs up icon.

After arriving in the school, she took off the mask, and check the air quality once again; the outdoor air quality is still very unhealthy. Veera thinks that she might talk about this unhealthy air quality and its health impact to her friends who do not care it very much, since she regards it as a very important issue for everyone (4).

Around 20:00, she checks outdoor air quality before heading back to her home. The application says that the outdoor air quality is clean now (5). Now she feels relieved, and goes to home without the mask (6).

Figure 55: <Veera's story #3: Wear a mask>

ANALYSIS OF VEERA'S STORY #3

In this story, Veera had a strong motivation towards an action due to the hazardous physical context (See 2.1.1 Context). To bring the strong motivation through visual communication, the application used powerful visual languages: an emoticon illustrating an extreme emotion with red color arousing viewer's attention and massive dust particles (See Figure 56 (40)). Along with it, it also delivered detailed information for satisfying Veer's curiosity regarding the situation (40-42).

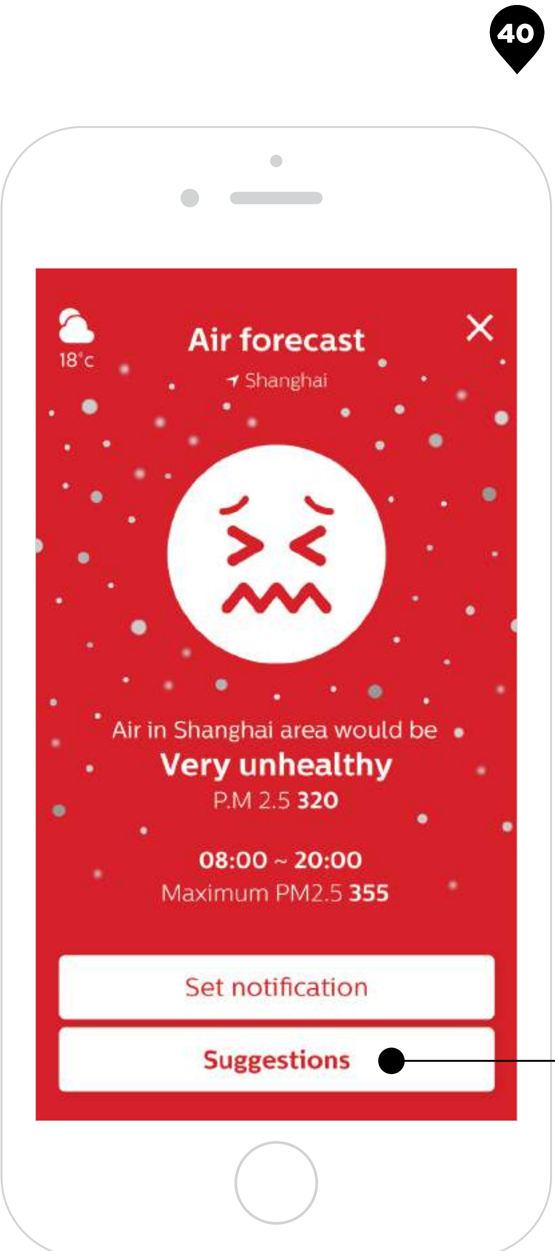
When she checked the first alert on her mobile (external trigger) (45), it instantly triggers her awareness regarding the situation and make her to follow detailed information (See 2.1.2.1 Trigger).

For her, wearing a mask was already an essential option to satisfy her purpose – going to the school while protecting herself from very unhealthy air quality. Even though the simplicity of the behavior was relatively lower in comparison to other behaviors, Veera's strong motivation satisfied the behavior model (See Figure 5), so she could finally choose to wear a mask.

Rewards she would get from her behavior consisted of an applause message while she was walking to a bus stop and constantly updated the air status (48). By being able to check the changed air quality in real time, she could have unexpected variable rewards (See 2.1.2.2 Habitual Behavior) (50).

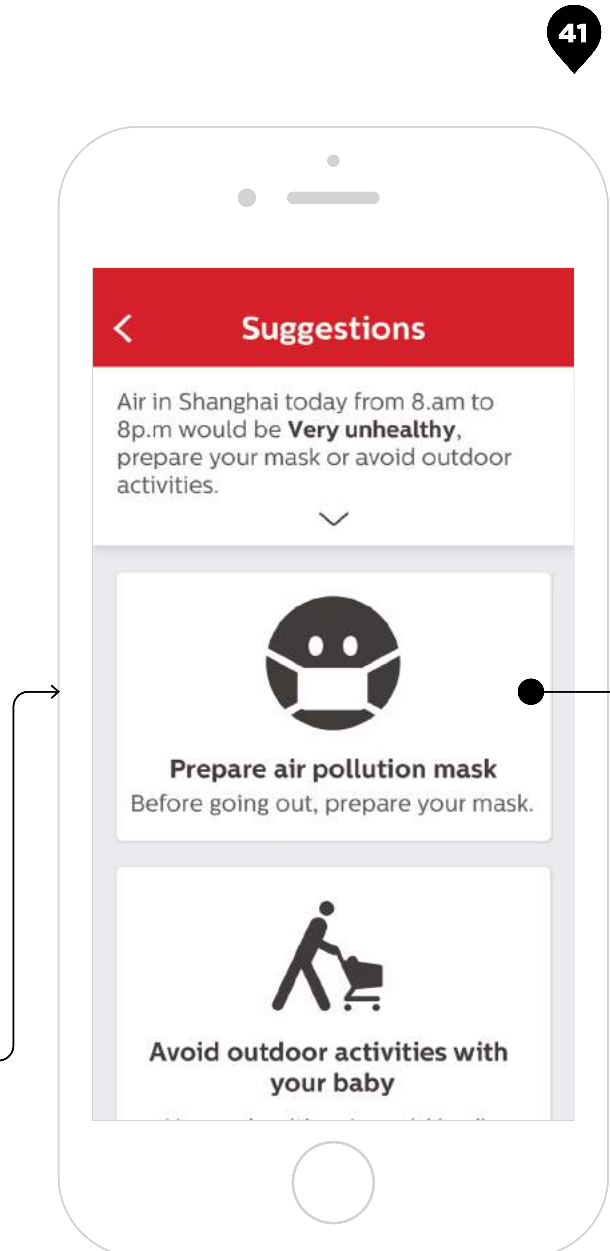
Additionally, she had another motivation telling the information to her friends as a storyteller (See 5.1.3.1 Storytelling for Others). Throughout it, the delivered information to Veera could be distributed to other people, which could ultimately affect arousing others' awareness and motivation.

Figure 56: <UI design #3: Wear a mask>



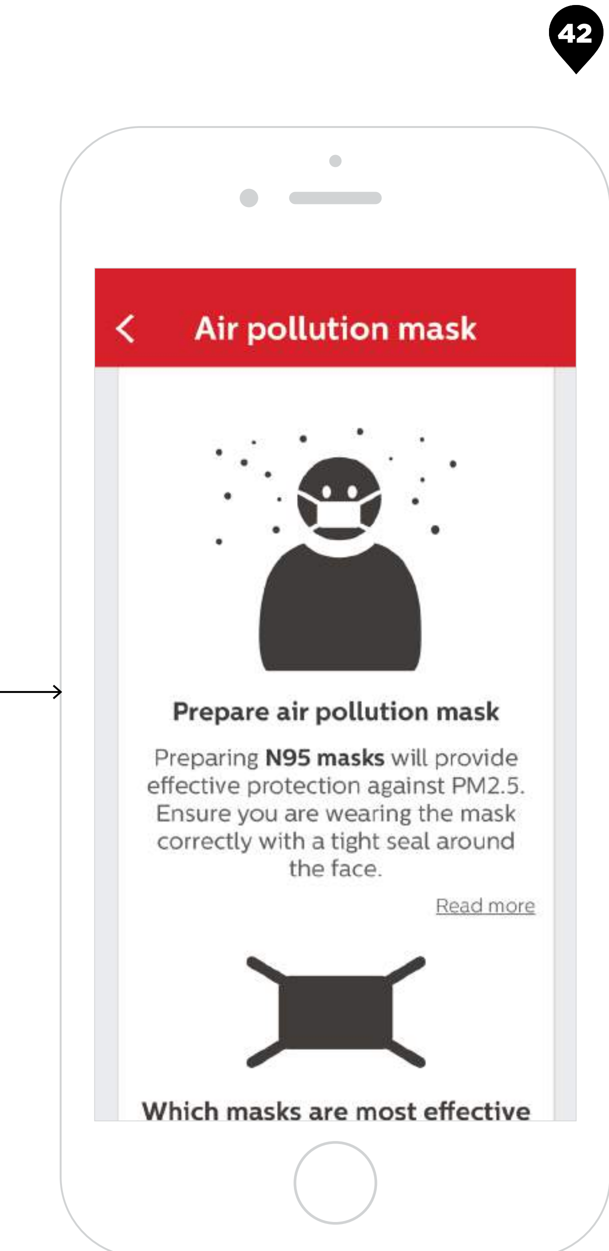
AIR FORECAST: VERY UNHEALTHY AIR

Veera gets an alert which says that the air quality will be very unhealthy.



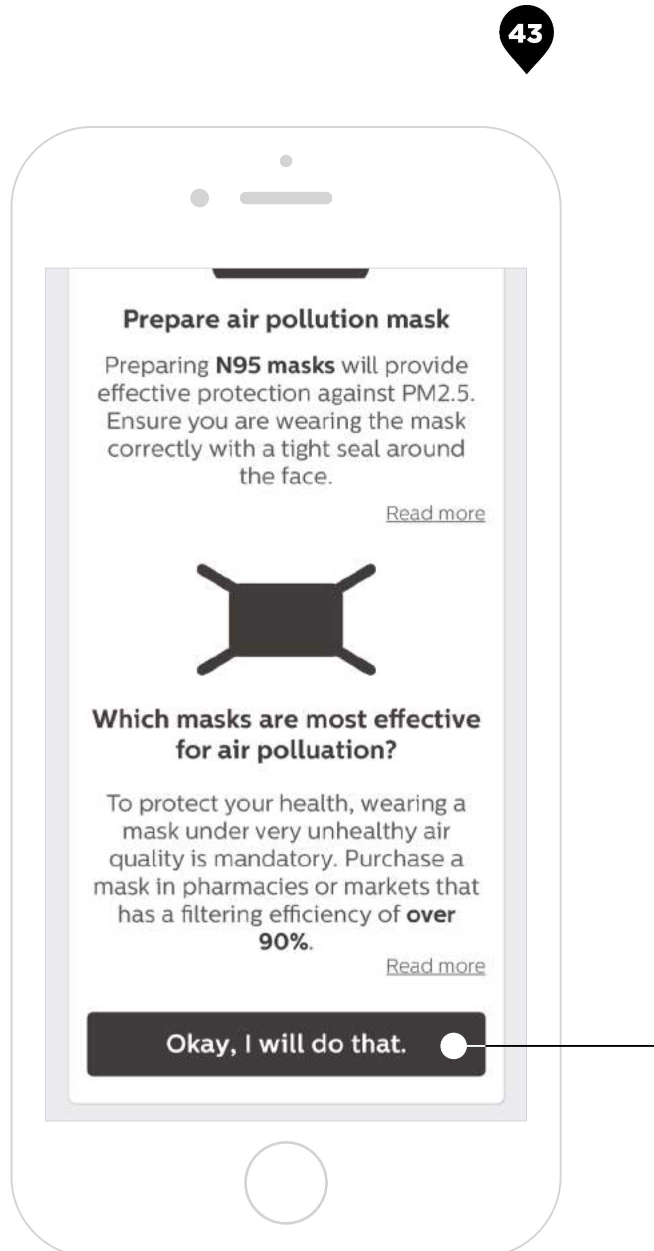
SUGGESTIONS

The app suggests possible behaviors that Veera can choose in the situation. Veera taps ‘prepare air pollution mask’.



PREPARE A MASK_1

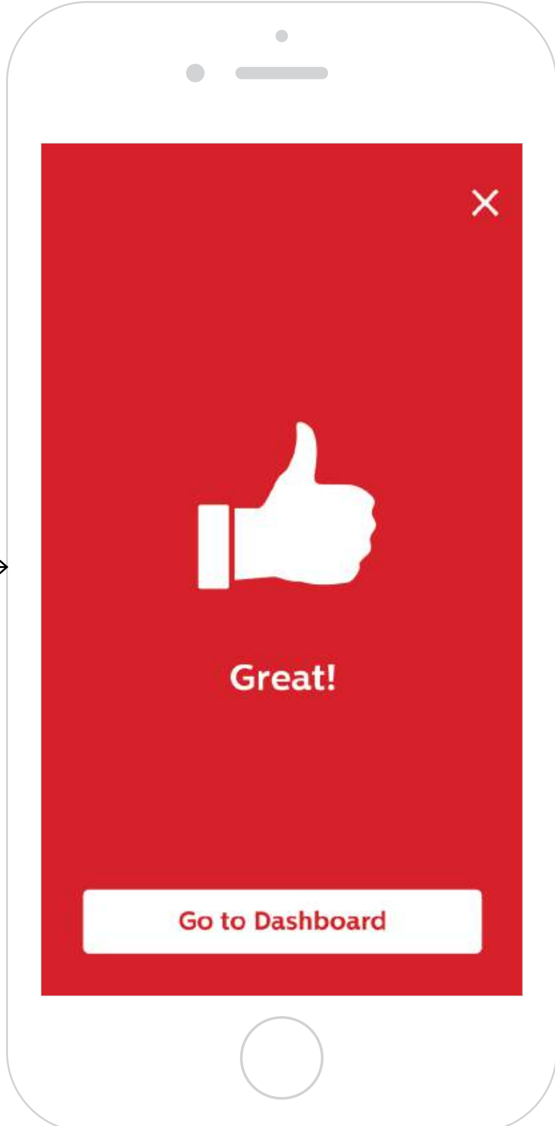
Veera sees more detailed explanations regarding preparing the mask.



PREPARE A MASK_2

After reading it, she tabs ‘Okay, I will do that’.

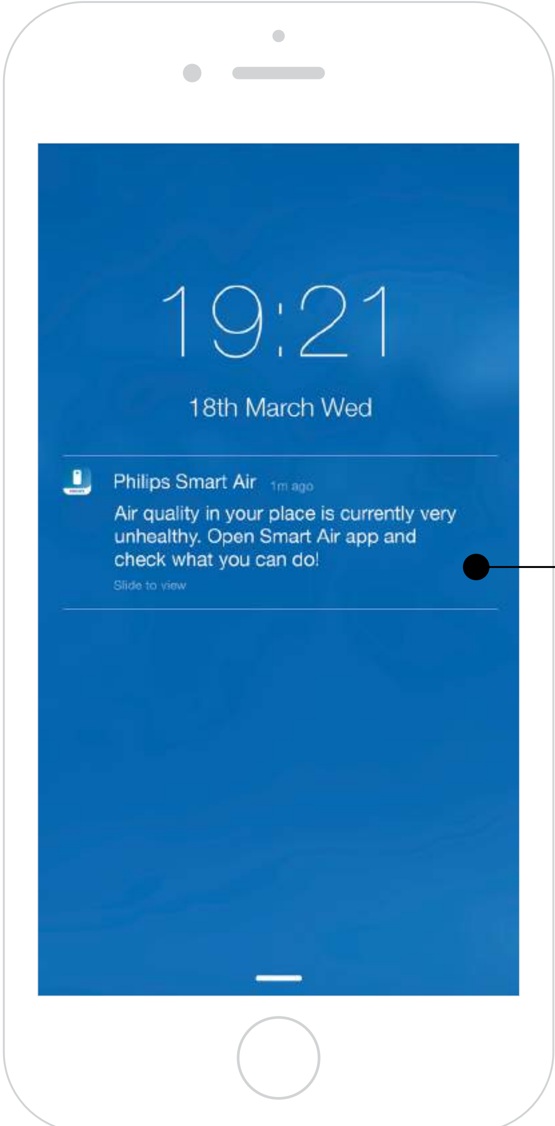
44



COMPLIMENT

The app gives applause for Veera's choice.

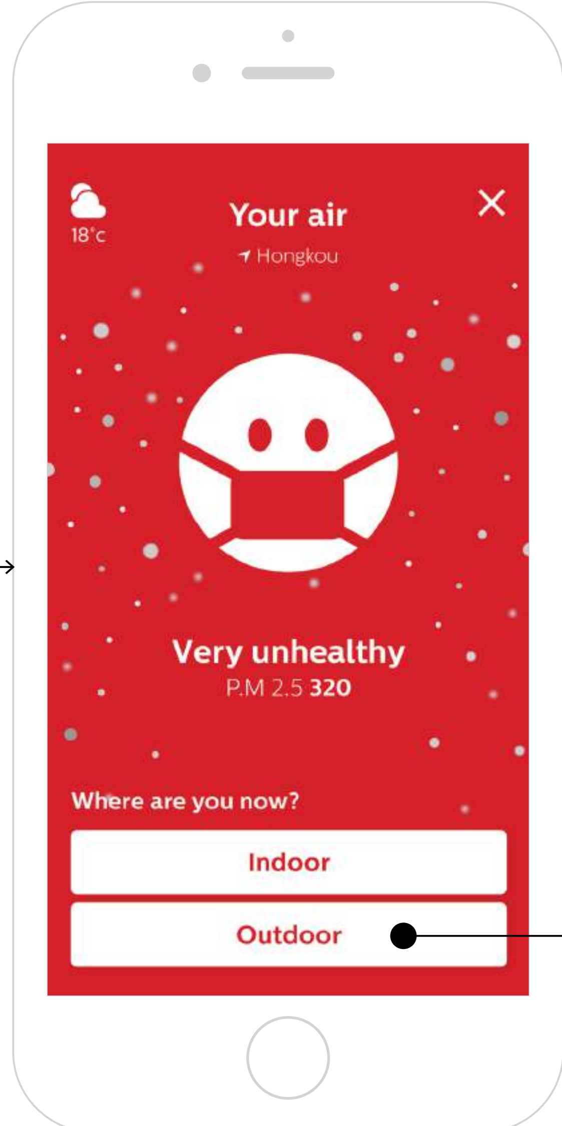
45



AIR NOTIFICATION: VERY UNHEALTHY

While Veera is walking outside, Smart Air Detector sends air data to her mobile that the current air is very unhealthy.

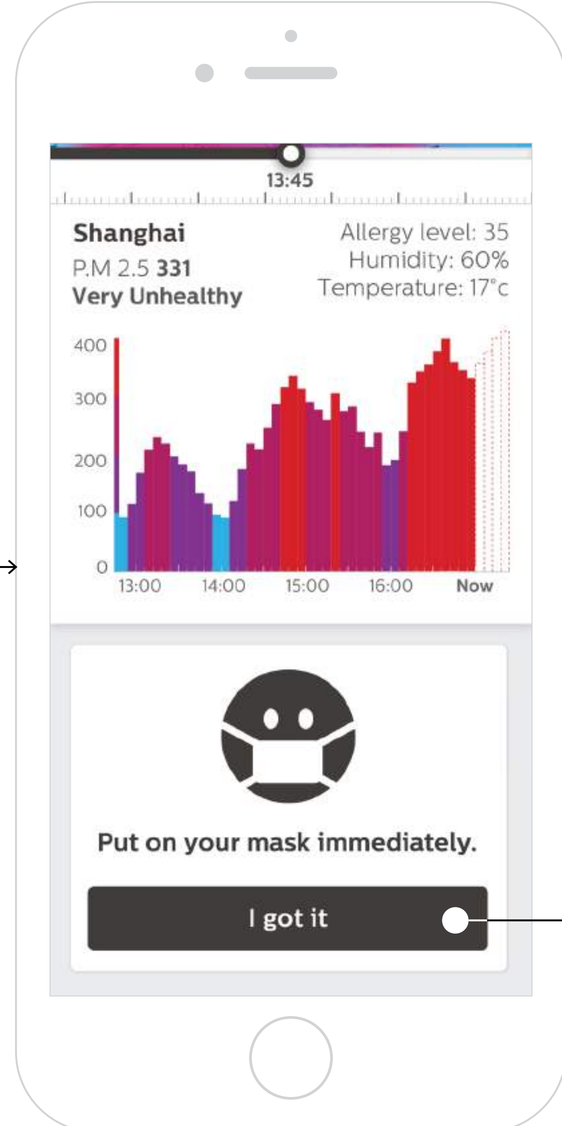
46



UNHEALTHY AIR

Veera can see the current air quality in which she is standing now.

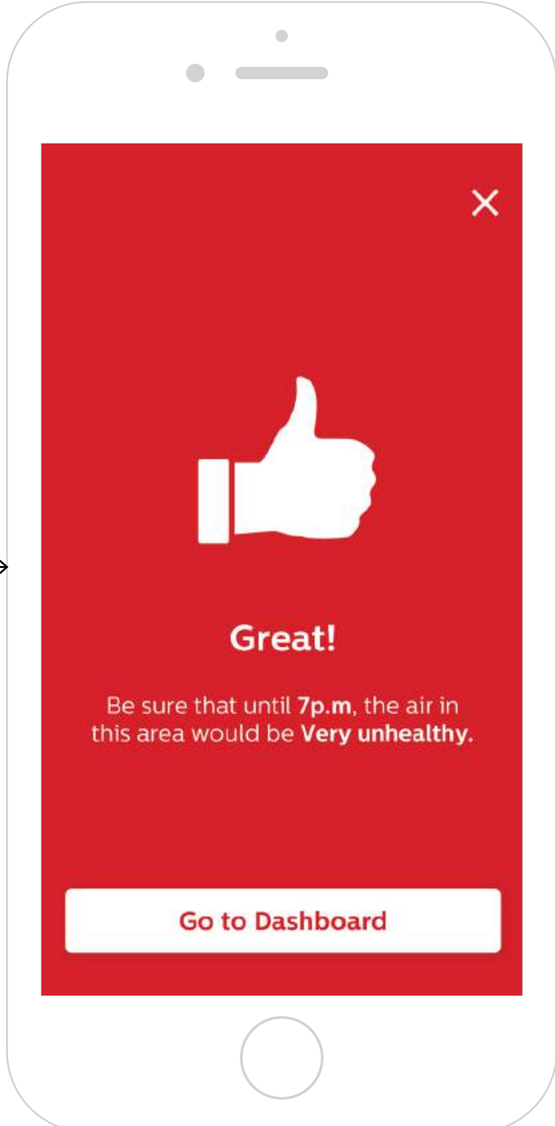
47



SUGGESTIONS

The app suggests wearing a mask immediately.

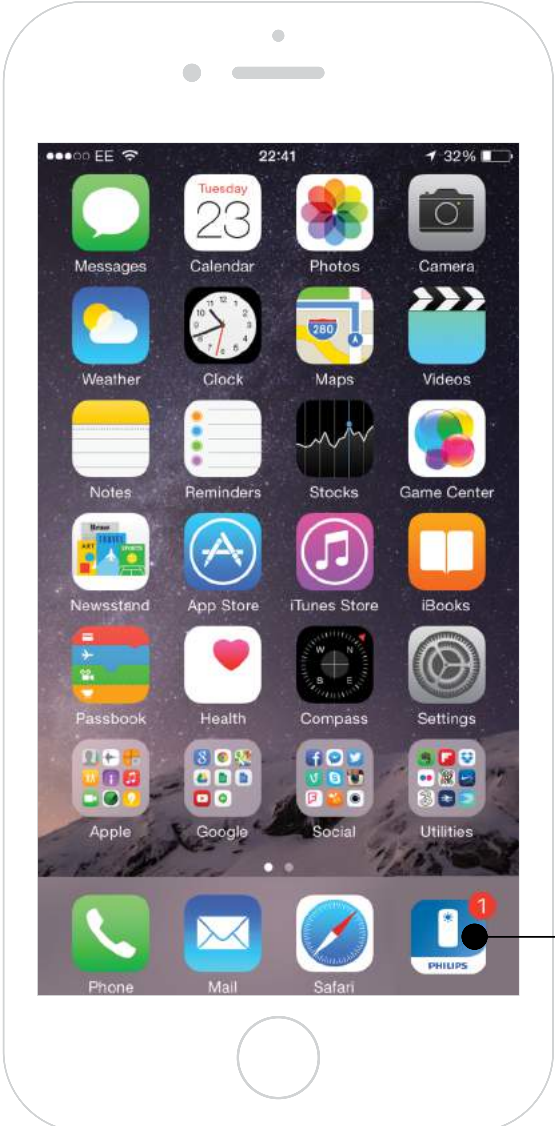
48



COMPLIMENT AFTER WEARING A MASK

The app gives applause for Veera's choice.

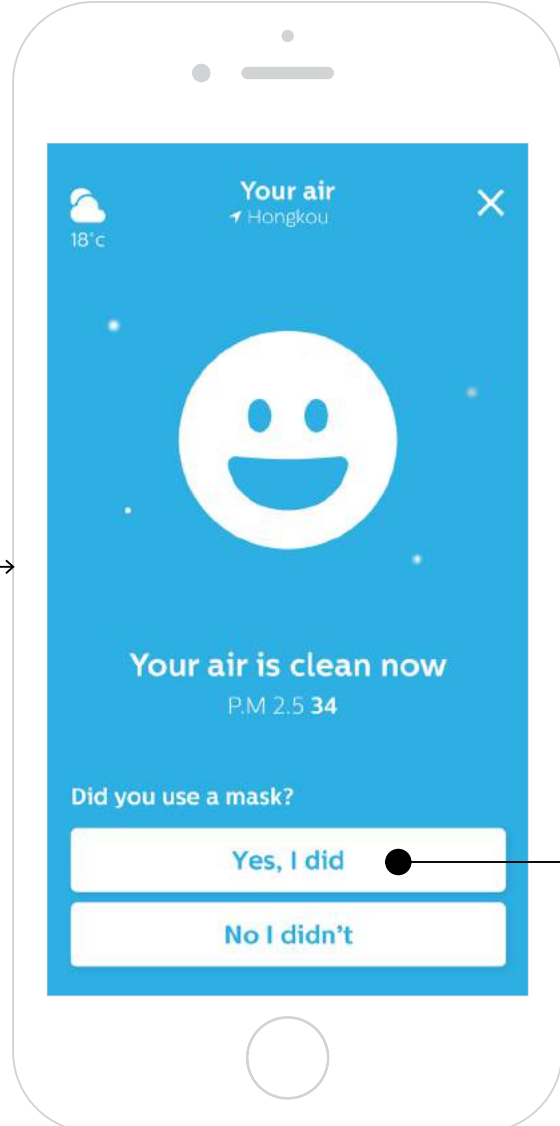
49



UNREAD MESSAGE

Around 20:00, Veera finds one unread message in the app.

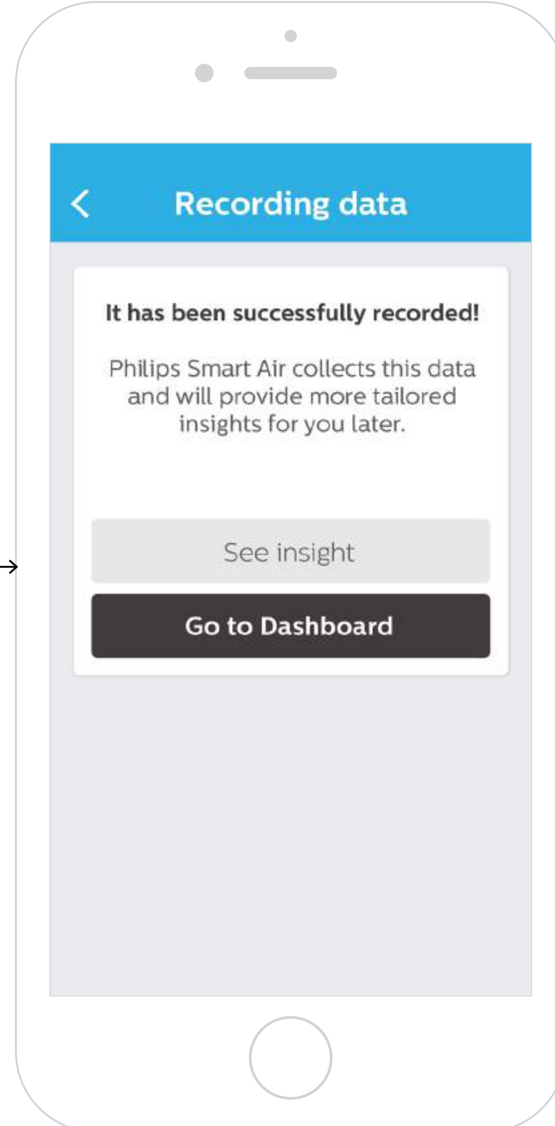
50



CLEAN AIR

The app lets Veera know about the cleaned air and asks whether she wore a mask or not.

51



RECORDING DATA

It records the data, and use it for making personalized insights.

"I love how all the insights have lead to
a great design concept that has a lot of
research, learnings and iterations behind…
the Smart Air Detector would be the best
tool for real time context information,
being locally relevant and people relevant."

- A reflection from Philips, 2016

6. CONCLUSION

This Master of Arts thesis has investigated the role of visual communication design for behavior change of people who are differently motivated in the context of air quality. It has endeavored to bring forth fundamental understandings of human behavior and visual communication design by conducting desk and user researches and shift the findings into an empirical case study. As the final design outcomes, this thesis proposed a real-time data measuring device for air quality along with a renewed mobile application. The final design outcomes challenged the target behaviors of a selected target user group. The result of interventions by the 2nd user evaluations was positive; evaluators were willing to change their behaviors to improve air quality surrounding them.

The research question in this thesis was; 'how visual communication would influence the behaviors of users who are differently motivated to improve air quality'. Based on the research question, it also built a hypothesis; 'depending on the users' motivation levels in the context of air quality, the roles of visual communication for behavior change would be different'.

In the desk research, the study explored theoretical frameworks in the fields of human behavior and visual communication design and compared it to the possibilities of visual stimulus to influence the users' behaviors. The acquired knowledge from the desk research was applied to the user research; an Online survey, user interviews and Co-Design workshops, by specifically focusing on the users' diverse motivational levels in the context of air quality. The case study examined a product: Philips Smart Air Purifier, based on findings and insights from the desk and the user research throughout the iterative design process: quick prototypes and user evaluations. Consequently, it proposed two new design concepts: Smart Air Detector and a renewed Philips Smart Air – mobile application, which challenges the target behaviors of User Group 2 by stimulating the users' perceptual systems throughout diverse visual languages.

Throughout these researches, the hypothesis was conclusively proved; visual interventions aiming to effectively change behaviors of users should reflect their motivation levels in the context of air quality. In detail, interventions through simplified sensory visuals stimulating the automatic system would be more persuasive for individuals in User Group 2, because their motivation is not high enough to accept a much detailed information. On the contrary, in the case of User Group 3, interventions can convey a more detailed information via arbitrary symbols such as long texts, numbers and graphs, since they have specific needs due to their contextual traits.

Based on the proved hypothesis, the research question was also answered. By designing visual languages that can increase users' awareness and motivation in the context of air quality, interventions could effectively influence the behaviors of users who are differently motivated. Since the study identified that being aware of a subject is the first step to change (Brewer and Rimer, 2008, p. 155; Prochaska et al., 2008, p. 101), increasing the users' awareness through visual communication is essential to develop their motivational levels, which ultimately influence the behavior change. To increase users' awareness and motivation to improve air quality, the study built an adapted behavior model and suggested three auxiliary methods. It consists of 1) visualizing the invisible air qualities to enhance experience of users, 2) layering information structure to deliver context-relevant information, and 3) providing personalized functions and information to support users' contextual differences (See 3.4.4 The Synthesis of Research Findings and Insights; 4.1 Project Overview).

—

6.1 PERSONAL REFLECTION

During the 9 months of study for this thesis, I have found out that changing one's behaviors through visual communication is a challenging task. In the beginning of the study, changing someone's behaviors seemed like too ambiguous and difficult. Even during the study, I realized that there are numerous factors influencing a behavior, and even the same elements could be differently understood by individuals. Making a habitual behavior was more difficult than bringing a behavior change. Due to these reasons, I was somewhat skeptical and critical regarding the subject – changing a behavior by a design, to a point.

However, after finalizing various researches and the case study, I have seen a possibility that visual designs can strongly influence people's behaviors and attitudes by considering how a behavior works, and how visual stimulus operate within the perceivers' minds. If someone says that a visual design can change everyone's behaviors, I would say that it is probably a wrong assertion. However, the visual communication still has a big potential that could impact people's lives, increase their awareness for situations surrounding them, and develop their motivation to do a behavior and finally induce persistent changes in their behaviors and attitudes. The important thing is that designers, including me, understand the ways of influencing people's behaviors properly, use the knowledge in designing a product or service and keep examining whether the interventions are successful or not.

—

6.2 LIMITATIONS OF THE STUDY AND SUGGESTIONS FOR FUTURE STUDY

This thesis started from the interpretation of the human behavior and visual communication in a specific context: air quality. To conduct a successful study and bring concrete results, focusing on a particular subject was inevitable. Even though the findings and insights from previous desk researches are universal knowledge that could be used for various purposes, the fundamental elements that influence designing interventions come from the understandings of people's desires and their contextual differences. In other words, depending on the subjects, e.g., game, children's habit, public health and more, design outcomes using the same theoretical frameworks could be comprehensively different. For the reason, the cornerstones of designing interventions for future study should be achieved by qualitative researches with empathic approaches to people while having the radical interpretation of theories in visual communication design and behavior change.

One of the limitations that this study had was narrowing focus on specific environmental and cultural contexts. Considering that the subject of this thesis: air quality, is significantly dependent on various contexts of people that ultimately influence designing interventions, having a focus on a particular context would bring more explicit results at the end of the study. For example, China is a country that has significant air quality issues in everyday life as well as being a big market for air business. If this study focused on environmental contexts of China and investigated their cultural singularities more, the anticipated impact of interventions could be more influential.

In addition, a comprehensive understanding on different motivations of other user groups is also necessary for the future researches. Since this thesis is mainly focused on User Group 2, it would have missed diverse perspectives from various users who have different motivational levels. More chances would be gained to increase the likeness of changing behavior through deeper understanding on the diverse resources of different motivations.

Furthermore, to properly evaluate the success in target behaviors, the future study has to assess the changed behaviors of users over a longer period of time to see if the behavior changes through visual communication designs were sustained or not.

REFERENCE

- Ackerman, D. (1990) A natural history of the senses. 1st edn. New York: Random House.
- Adolphs, R. (2003) 'Cognitive neuroscience of human social behaviour', Nature Reviews: Neuroscience, 4(3), pp. 165–178.
- Brewer, N. T. and Rimer, B. K. (2008) 'Perspectives on Health Behavior Theories That Focus on Individuals', Health Behavior and Health Education: Theory, Research, and Practice, pp. 149–165.
- Brown, T. and Katz, B. (2009) Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, HarperCollins.
- Castillo, J. J. (2009) Convenience sampling, Explorable.com. Available at: Resources: http://www.experiment-resources.com/convenience-sampling.html.
- Deci, E. L. and Ryan, R. M. (2008) 'Self-determination theory: A macrotheory of human motivation, development, and health.', Canadian Psychology/Psychologie canadienne, 49(3), pp. 182–185.
- Dimberg, U., Thunberg, M. and Elmehed, K. (2000) 'Unconscious facial reactions to emotional facial expressions.', Psychological science : a journal of the American Psychological Society / APS, 11(1), pp. 86–89.
- Dunn, W., and Brown, C. (1994) 'The Ecology of Human Framework for Considering the Effect of Context', American Journal of Occupational Therapy, 48, pp. 595–607.
- EPA (2013) An Introduction to Indoor Air Quality(IAQ), United States Environmental Protection agency. Available at: http://www.epa.gov/iaq/voc.html.
- Van Essen, D. C., Anderson, C. H. and Felleman, D. J. (1992) 'Information processing in the primate visual system: an integrated systems perspective.', Science, 255, pp. 419–23.
- Evans, G. W. and Jacobs, S. V. (1981) 'Air Pollution and Human Behavior', Journal of Social Issues, 37(1), pp. 95–125.
- Eyal, N. (2014) Hooked How to Build Habit-Forming Products. New York, New York: Portfolio/Penguin.
- Fogg, B. J. (2003) Persuasive Technology: Using Computers to Change What We Think and Do, Persuasive Technology Using Computers to Change What We Think and Do.
- Fogg, B. J. (2009) 'A behavior model for persuasive design', Proceedings of the 4th International Conference on Persuasive Technology - Persuasive '09.
- Gibson, J. J. (1966) The Senses Considered as Perceptual Systems. Boston: Houghton Mifflin.
- Gibson, J. J. (1977) 'The Theory of Affordances', Perceiving, Acting, and Knowing.
- Gibson, J. J. (2002) Vision and Mind - Selected Readings in the Philosophy of Perception, A Theory of Direct Visual Perception.
- Gregory R. L. (1970) Intelligent Eye. 1st editio. McGraw Hill Book Company.
- Haahtela, T., von Hertzen, L., Mäkelä, M. and Hannuksela, M. (2008) 'Finnish Allergy Programme 2008-2018--time to act and change the course.', Allergy, 63(6), pp. 634–45.
- In, H. J. and Park, S. U. (2002) 'A simulation of long-range transport of Yellow Sand observed in April 1998 in Korea', Atmospheric Environment, 36(26), pp. 4173–4187.
- Khaled, R., Biddle, R., Noble, J., Barr, P. and Fischer, R. (2006) 'Persuasive Interaction for Collectivist Cultures', in Conferences in Research and Practice in Information Technology Series, pp. 63–70.
- Landy, F. J. and Conte, J. M. (2007) Work in the 21st century: An introduction to industrial and organizational psychology (2nd ed.)., Work in the 21st century: An introduction to industrial and organizational psychology (2nd ed.).
- Ledger, D. and McCaffrey, D. (2014) 'Inside Wearables: How the Science of Human Behavior Change offers the Secret to Long-Term Engagement', Endeavorpartners, (January), pp. 1–17.
- Lucke, J. (2013) 'Context Is All Important in Investigating Attitudes: Acceptability Depends on the Nature of the Nudge, Who Nudges, and Who Is Nudged', The American Journal of Bioethics. Taylor & Francis, 13(6), pp. 24–25.
- McLeod, S. A. (2007) 'Visual Perception Theory', Simply psychology. Available at: www.simplypsychology.org/perception-theories.html.
- Mearian, L. (2011) World's data will grow by 50x in next decade, IDC study predicts., Computerworld from IDG. Available at: http://www.computerworld.com/article/2509588/data-center/world-s-data-will-grow-by-50x-in-next-decade--idc-study-predicts.html.
- Nielsen, J. (1993) 'Iterative User Interface Design', IEEE Computer, 26(11), pp. 32–41.
- Norcross, J. C., Mrykalo, M. S. and Blagys, M. D. (2002) 'Auld lang syne: Success predictors, change processes, and self-reported

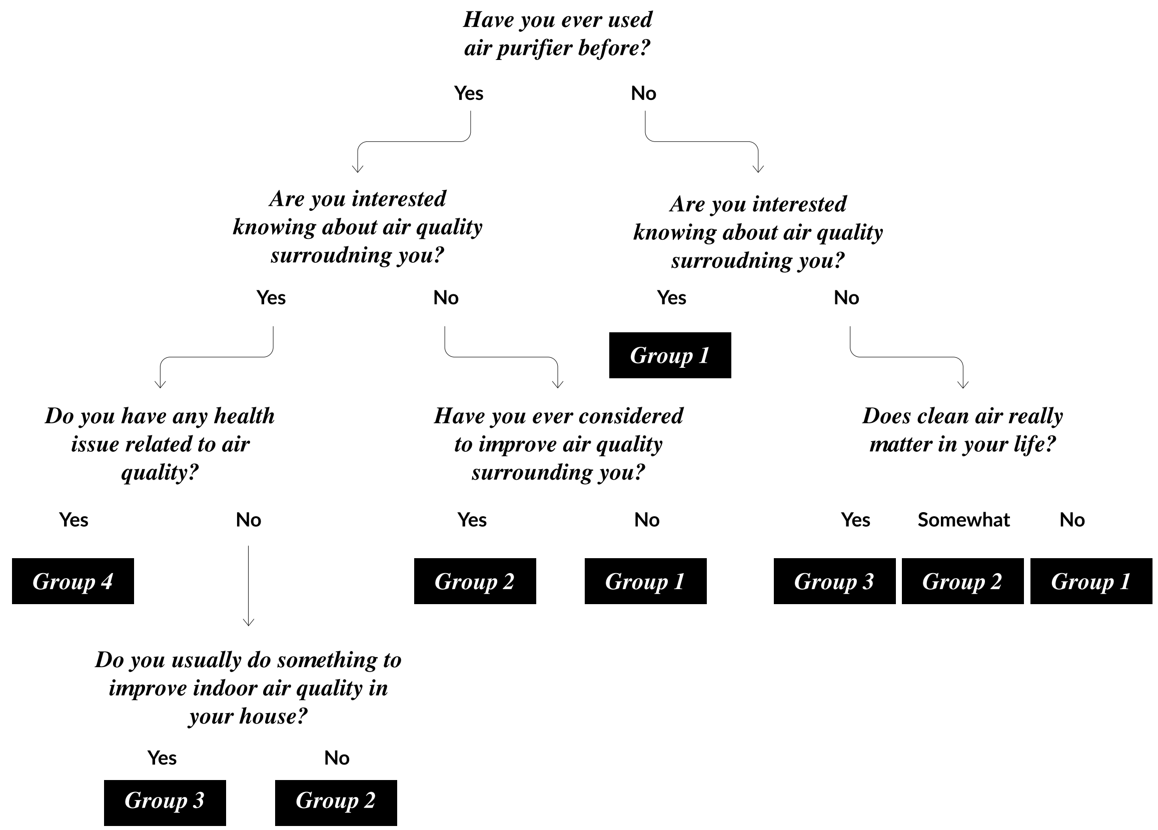
outcomes of New Year's resolvers and nonresolvers', Journal of Clinical Psychology, 58(4), pp. 397–405.

- Norman, D. (2015) Does Culture Matter for Product Design?, Core 77. Available at: http://www.core77.com/posts/21455/does-culture-matter-for-product-design-21455
- Norman, D. A. (2002) The Design of Everyday Things, Human Factors and Ergonomics in Manufacturing.
- O'Connor, K. (2011) Personas: The Foundation of a Great User Experience, UX Magazine.
- OED, O. (2016a) 'data, n.' The Oxford English Dictionary, Oxford University Press. Available at: http://www.oxforddictionaries.com/definition/english/data.
- OED, O. (2016b) 'semiotics, n.' The Oxford English Dictionary, Oxford University Press. Available at: http://www.oxfordlearnersdictionaries.com/definition/english/semiotics?q=semiotics.
- Phelps, E. A. (2006) 'Emotion and Cognition: Insights from Studies of the Human Amygdala', Annual Review of Psychology, 57(1), pp. 27–53.
- Philips (2013) Philips boosts Air Portfolio with Smart Purifier Announced at IFA 2013, Philips Media. Available at: http://releasd.com/7bf8/philips-boosts-air-portfolio-with-smart-purifier-announced-at-ifa-2013.
- Philips (2014) Philips launches Smart Air Purifier in China as the first result of the new partnership with Alibaba in cloud-based applications for a smarter and healthier lifestyle, Philips Media. Available at: http://www.philips.com/a-w/about/news/archive/standard/news/press/2014/20141014-Philips-launches-Smart-Air-Purifier-in-China-as-the-first-result-of-the-new-partnership-with-Alibaba.html.
- Philips (2014) Philips Smart Air Purifier User Manual, Philips Media. Available at: http://www.p4c.philips.com/cgi-bin/dcbint/cpindex.pl?ctn=AC4373/00&scy=CN&slg=en.
- Philips (2015) Philips Smart Air, iTunes. Available at: https://itunes.apple.com/us/app/philips-smart-air/id899485810?mt=8.
- Philips (2016) Philips Health Continuum. Available at: http://www.philips.co.uk/healthcare/about/events-calendar/mr-user-meeting-2015.
- Plutchik, R. (1980) Emotion: A Psychoevolutionary Synthesis, NY Harper and Row.
- Prochaska, J. O., Redding, C. A. and Evers, K. E. (2008) 'The Transtheoretical Model and Stages of Change', Health Behavior and Health Education. Theory Research and Practice, pp. 97–121.
- Radomski, M. V. (2008) 'Assessing context: personal, social, and cultural', Occupational Therapy for Physical Dysfunction. 6th ed. Philadelphia: Lippincott, Williams & Wilkins, pp. 285–309.
- Raihani, N. J. (2013) 'Nudge politics: Efficacy and ethics', Frontiers in Psychology.
- Rhodan, M. (2015) Study Finds Pollution in China Causes 1.6 Million Deaths a Year, Time.
- Ryan, R. and Deci, E. (2000) 'Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions.', Contemporary educational psychology, 25(1), pp. 54–67.
- Saldana, J. (2009) 'The Coding Manual for Qualitative Researchers', The coding manual for qualitative researchers.
- Salvetti, B. (2016) Digital Stress: What is it, how does it affect teens and how can you help?, Children's Hospital Los Angeles. Available at: http://www.chla.org/blog/rn-remedies/digital-stress-what-it-how-does-it-affect-teens-and-how-can-you-help.
- Sanders, E. B.-N. and Stappers, P. J. (2008) 'Co-creation and the new landscapes of design', CoDesign, 4(1), pp. 5–18.
- Sapolsky, R. (2013) Are Humans Just Another Primate?, FORA.tv. Available at: http://library.fora.tv/2011/02/15/Robert_Sapolsky_Are_Humans_Just_Another_Primate#fullprogram.
- Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., Griskevicius, V., Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J. and Griskevicius, V. (2013) 'The Constructive , Destructive , and Reconstructive Power of Social Norms', pp. 429–434.
- Shedroff, N. (1994) 'Information Interaction Design: A Unified Field Theory of Design', Information design.
- Stokols, D. (1996) 'Translating social ecological theory into guidelines for community health promotion', American Journal of Health Promotion, pp. 282–298.
- Strasser, E., Weiss, A., Grill, T., Osswald, S. and Tscheligi, M. (2012) 'Combining implicit and explicit methods for the evaluation of an ambient persuasive factory display', Springer-Verlag Berlin Heidelberg, pp. 113–128.
- Thaler, R. H. and Sunstein, C. R. (2009) Nudge : improving decisions about health, wealth, and happiness, Nudge - Business Summaries. Penguin Books.
- Tikka, P., Woldemicael, B. and Oinas-Kukkonen, H. (2016) 'Building an App for Behavior Change: Case RightOnTime', Fourth International Workshop on Behavior Change Support Systems (BCSS'16), pp. 3–14.

- Tufte, E. R. (2001) The Visual Display of Quantitative Information, The Visual Display of Quantitative Information.
- Turner, D. W. (2010) ‘Qualitative interview design: A practical guide for novice investigators’, The Qualitative Report, 15(3), pp. 754–760.
- Vince, G. (2013) Cities: How crowded life is changing us, BBC. Available at: http://www.bbc.com/future/story/20130516-how-city-life-is-changing-us
- Wallbott, H. G. (1991) ‘Recognition of emotion from facial expression via imitation? Some indirect evidence for an old theory’, British Journal of Social Psychology, 30(3), pp. 207–219.
- Ware, C. (2004) Information visualization: perception for design, Information Visualization.
- Webster’s new world dictionary. 3rd colleg (1994). New York: Prentice Hall.

APPENDICES

APPENDIX 1: <INTRODUCTORY QUESTIONS FOR IDENTIFYING USER GROUPS>



APPENDIX 2: <QUESTIONS FOR ONLINE SURVEY>

1. Universal questions

Q. Do you live with your family?
Q. Do you have any family member who is vulnerable to air quality?
Q. Do you live in a region that have some air issues? If you live in the region, tell me about the outdoor air environment.
Q. What do you think the most important things to improve air quality in your home?
Q. What would make indoor air quality better in your house?
Q. How many times do you open windows to ventilate and when do you do it?
Q. Do you know when is the right time to open your window?
Q. What kind of information do you want to know related with air quality?

- *The current state of indoor air quality*
- *The current state of outdoor air quality*
- *The current state of neighborhood air quality*
- *The current state of air quality in a specific region*
- *The ways of improving your house air quality*
- *The cause of bad air quality in your house*
- *The hourly changes of indoor air quality*
- *The hourly changes of outdoor air quality*
- *The relationship between health and air quality*
- *The influences of bad air quality on human body (e.g., possible diseases that can happen, if someone is exposed under certain level of air quality, possible different influences of bad air quality for vulnerable people.*
- *Others*

Group 1
Q. Can you tell the reason why you're not so interested in air quality?

Read this information, and answer with following question.

"Chemical gaseous pollutants to be 2 to 5 times higher inside home than outside, regardless of whether the homes were located in rural or highly industrial areas (EPA, 2013)."

"Worldwide Health Organization declared air pollution a group 1 carcinogenic having the potential to cause cancer in 2010 (IARC, 2013) and US Environmental Protection Agency (EPA) calls indoor air pollution one of the top 5 environmental health risks (EPA, 2013)."

"An investigation amongst US residents found that, on average, individuals spent 88% of their day inside buildings, and 7% in a vehicle. Only 5% of participants' time was actually spent outside (Robinson & Nelson, 1995)."

"An investigation amongst US residents found that, on average, individuals spent 88% of their day inside buildings, and 7% in a vehicle. Only 5% of participants' time was actually spent outside (Robinson & Nelson, 1995)."

Q. Would this information change your mind about air quality?

Group 2
Q. If you are using or used to use air purifier, when do(did) you use air purifier?
Q. If you are currently using air purifier(s), why do you use it?

Group 3
Q. If you are using or used to use air purifier, when do(did) you use air purifier?
Q. If you are currently using air purifier(s), why do you use it?
Q. Can you tell the reason why you care about air quality?

Group 4
Q. If you are using or used to use air purifier, when do(did) you use air purifier?
Q. If you are currently using air purifier(s), why do you use it?
Q. Can you tell the reason why you care about air quality?

APPENDIX 3: <QUESTIONS FOR USER INTERVIEWS>

1. Understanding users' contexts: physical, personal, social and cultural

Q. Are you currently using air purifier(s) or used to use?
Q. How's your house size and how many products are you using?
Q. Which Air Purifier brand do you use? With the brand, how do you feel about the product? Is it smart air purifier or just a product?
Q. Do you have family members who live together? If it is, how does it influence to use air purifier? How do your other family members use it?
Q. Do you have any respiratory issues?
Q. How often do you change the filter of the air purifier? How do you know it?
Q. How's air condition in the region where you are currently living? Is it related to use of the product?

2. Motivation of using air purifier (Extrinsic)

Q. Why do you use air purifier? Three main reasons.
Q. How many years have you used the product?
Q. How often do you use?
Q. When do you use the product in your day?
Q. Tell me about the story how do you usually use the product. (Find trigger to use the product.)
Q. What makes you trigger to use the product in general?
Q. Are you going to use it in the future as well?
Q. Is it easy to use? If it is easy, why do you think that?

3. Motivation (Intrinsic)

Q. What would be the three elements of good air purifier for your life?
Q. What make you satisfied and frustrated to use air purifier? Three reasons for each
Q. Have you ever changed the product for different purposes?

4. Awareness and information

Q. Do you feel that your house air quality has improved since the time you started to use the product? If yes, why and how do you feel that? If no, why do you think that?
Q. How much do you know about the relationship between air quality and your health condition?
Q. Do you want to know that detailed information? Why?
Q. What do you want to know about? Tell me three things.

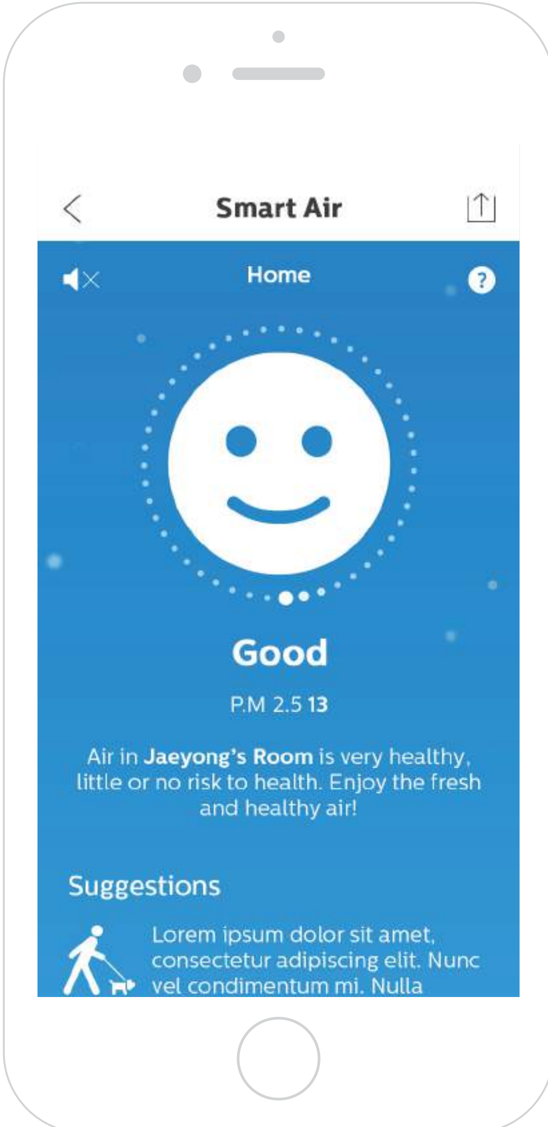
Workflow
Philips Smart Air iOS App

APPENDIX 4: <THE 1ST ITERATION: WORKFLOW DIAGRAM>

APPENDIX 5: <THE 1ST ITERATION: UI DESIGN>

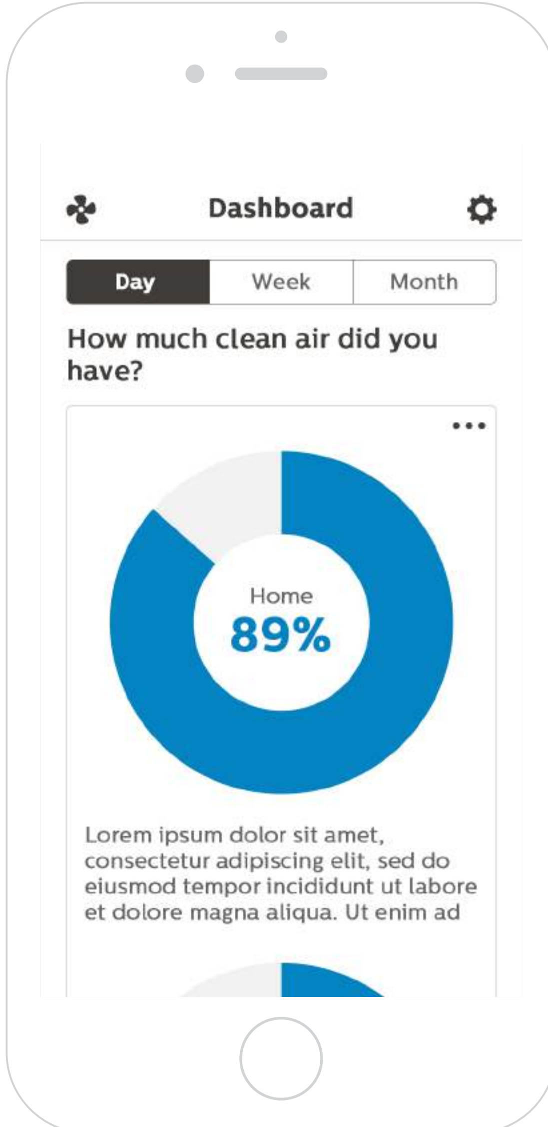
MAIN PAGE

The app highlights home air quality and outdoor air quality by dust and background animation.



MAIN PAGE - TAPPED

Shows more details either home air or outdoor air when one taps the screen. Gives simple suggestions and data visualizations.

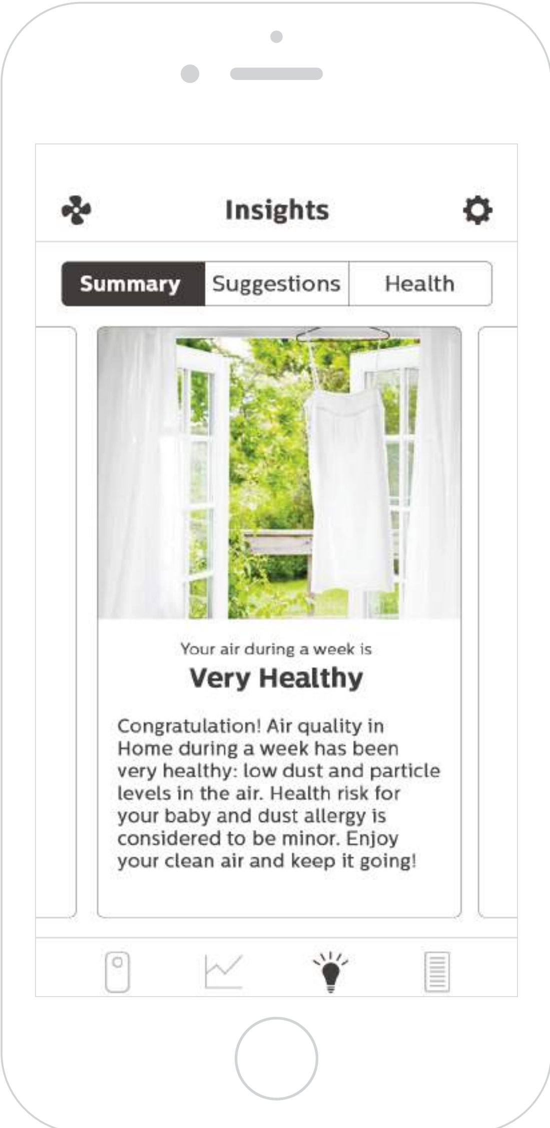


DASHBOARD_1

Illustrates diverse data collections by time: daily, weekly and monthly.

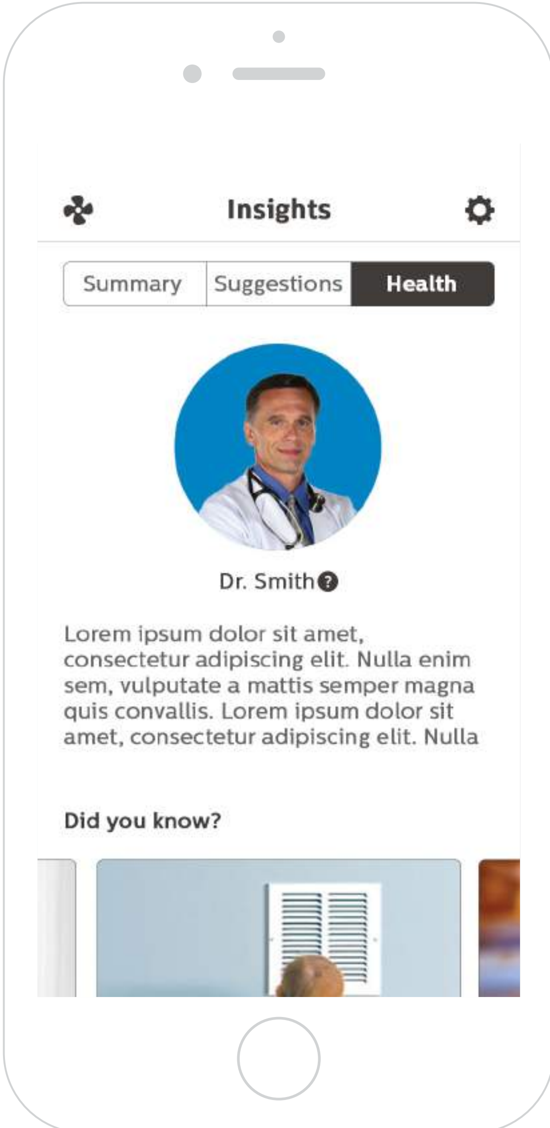
DASHBOARD_2

Illustrates diverse data collections by time: daily, weekly and monthly.



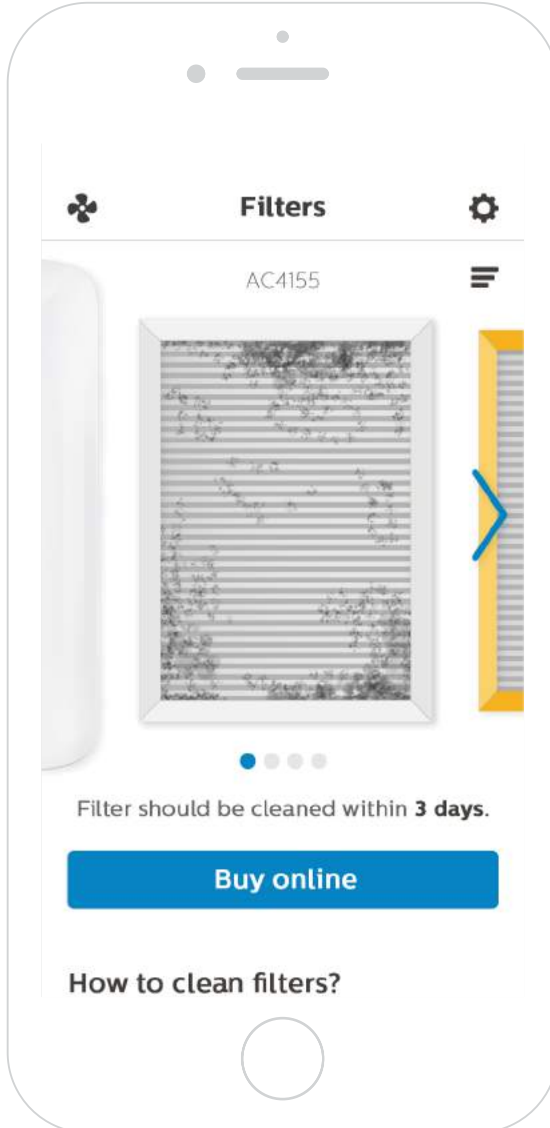
INSIGHTS - SUMMARY

Gives summarized insights based on collected air data.



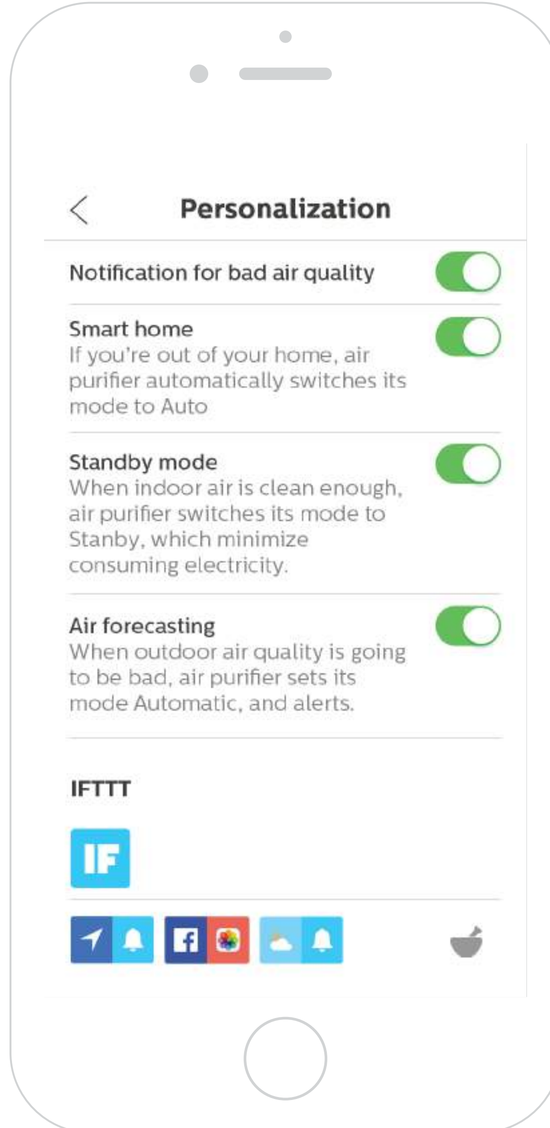
INSIGHTS - HEALTH

Conveys health information reflecting users' contexts.



FILTERS

Visualizes dust on filters to induce emotional interactions.



SETTINGS - PERSONALIZATION

Users can adjust functions based on their needs.

SITUATION 1

1. This information and interventions possibly change my behavior (Opening windows).

Strongly disagree — Disagree — Neutral — Agree — Strongly agree

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

2. I feel more motivated having clean air after using it.

Strongly disagree — Disagree — Neutral — Agree — Strongly agree

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

3. This information and interventions increase my awareness of having clean air.

Strongly disagree — Disagree — Neutral — Agree — Strongly agree

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

4. The behavior is easy to do.

Strongly disagree — Disagree — Neutral — Agree — Strongly agree

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

5. The provided information and interventions make the behavior easy to do.

Strongly disagree — Disagree — Neutral — Agree — Strongly agree

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

6. Information and interventions were properly provided on the right time.

Strongly disagree — Disagree — Neutral — Agree — Strongly agree

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

7. How do you feel it?

____

____

____

Visual Communication for Behavior Change:
Changing Users' Behaviors regarding Air Quality

2016

Author: Jaeyong Lee
Supervisor: Virpi Roto
Advisor: Virpi Roto
Partner of the study: Philips
Company Supervisor: Edward Tonino
Company Advisor: Escano Serrano, Carmen

Jaeyong Lee
jaeyonglee05@gmail.com
www.studiojaeyonglee.com
+358 (0)46 577 5140